MEXICO NUMBER

Volume 20 APRIL, 1936 Number 4

BULLETIN
of the
American Association *of* Petroleum Geologists

CONTENTS

Foreword: SYMPOSIUM ON MEXICO

Petroleum Geology and The American Association of Petroleum Geologists — *By A. Irving Levorsen* 387

Synopsis of the Geology of Mexico — *By Manuel Santillán* 394

Structural Geology of Border Province of Northeastern Mexico Adjacent to Zapata and Starr Counties, Texas — *By William G. Kane* 403

Paleogeography of Parts of Border Province of Mexico Adjacent to West Texas — *By Lewis B. Kellum* 417

Micropaleontology in Mexico with Special Reference to the Tampico Embayment — *By Reginald Wright Barker* 433

Geologic Road Log of Pan-American Highway, Laredo to Mexico City, with Map — *By San Antonio Geological Society* 457

Map of Regional Geology along National Railway of Mexico, Laredo to Mexico City — *By San Antonio Geological Society* 466

Geologic Road Log in Tamaulipas and Nuevo León, Mexico, with Map — *By San Antonio Geological Society* 467

GEOLOGICAL NOTES

Wells Drilled in Northeastern Mexico — *By William G. Kane* 478

Ouachita Boulder Problem, Oklahoma and Arkansas — *By William Kramer, Philip B. King, and Hugh D. Miser* 479

Distribution of Eocene Rocks in Santa Lucia Mountains, California — *By C. Lathrop Herold* 491

"Potamides Matsoni" Zone of Texas (Burkville Beds) — *By Alva C. Ellisor* 494

REVIEWS AND NEW PUBLICATIONS

Historical Geology of the Antillean-Caribbean Region — *Charles Schuchert* (Charles Laurence Baker) 496

Tertiary Faunas, Vol. I — *A. Morley Davies* (Alva C. Ellisor) 505

Recent Publications 506

THE ASSOCIATION ROUND TABLE

Membership Applications Approved for Publication 509

Association Committees 511

MEMORIAL

Charles Thomas Lupton — *C. J. Hares* 512

AT HOME AND ABROAD

Current News and Personal Items of the Profession 516

COPYRIGHT 1936, BY THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, INC.

KEYS to profits

The Baker Cable Tool Core Barrel enables you to proceed with positive knowledge of all factors to secure the greatest ultimate profits from your oil well.

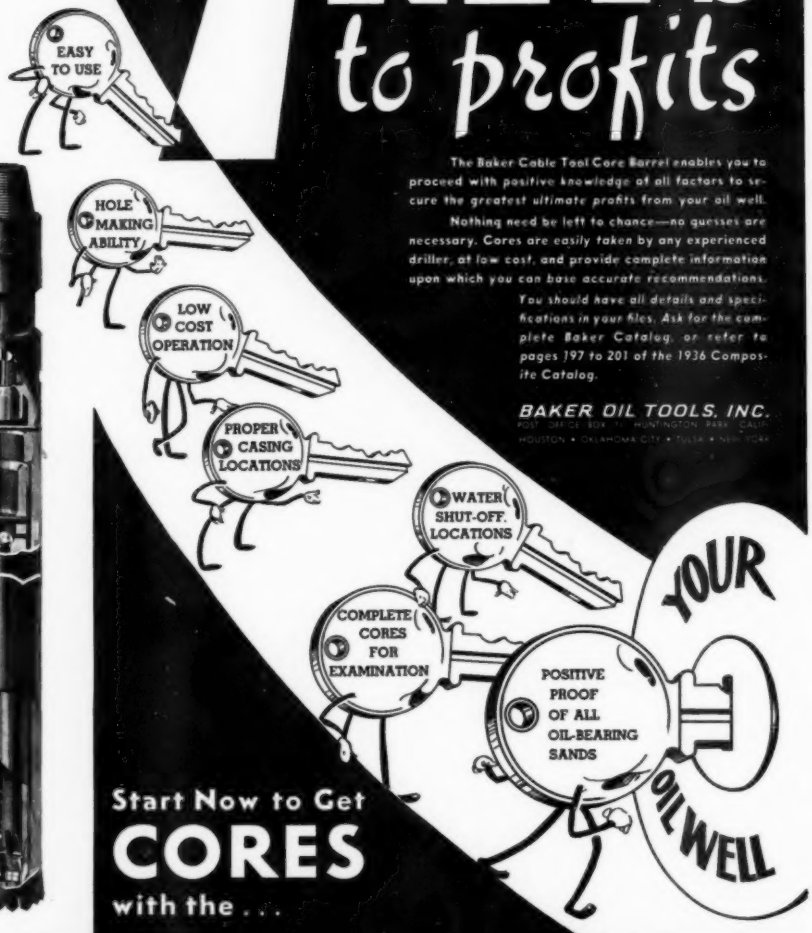
Nothing need be left to chance—no guesses are necessary. Cores are easily taken by any experienced driller, at low cost, and provide complete information upon which you can base accurate recommendations.

You should have all details and specifications in your files. Ask for the complete Baker Catalog, or refer to pages 197 to 201 of the 1936 Composite Catalog.

BAKER OIL TOOLS, INC.

POST OFFICE BOX 1... HUNTINGTON PARK, CALIF.

HOUSTON • OKLAHOMA CITY • TULSA • NEW YORK



Start Now to Get

CORES

with the . . .

BAKER CABLE TOOL CORE BARREL

BULLETIN

of the

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

OFFICE OF PUBLICATION, 505 TULSA BUILDING, TULSA, OKLAHOMA

L. C. SNIDER, *Editor*

CITIES SERVICE COMPANY, 60 WALL STREET, NEW YORK CITY

ASSOCIATE EDITORS

GENERAL	K. C. HEALD, The Gulf Companies, Box 1214, Pittsburgh, Pa. HUGH D. MISER, U. S. Geological Survey, Washington, D. C. THERON WASSON, Room 2308, 35 E. Wacker Drive, Chicago, Ill.
APPALACHIAN	
North	JOHN R. REEVES, Penn-York Natural Gas Corporation, Coudersport, Pa.
South	WILLIAM O. ZIEBOLD, 1572 Virginia Street, Charleston, W. Va.
NORTH CENTRAL STATES	W. A. THOMAS, The McClanahan Oil Company, Mt. Pleasant, Mich.
KANSAS	ANTHONY FOLGER, Gypsy Oil Company, Wichita, Kan.
OKLAHOMA	ROBERT H. DOTT, Oklahoma Geological Survey, Norman, Okla. GEORGE O. WILLIAMS, 2540 W. Twenty-Second St., Oklahoma City, Okla.
TEXAS	
North and Central	J. B. LOVEJOY, Gulf Production Company, Fort Worth, Tex.
Northeastern	E. A. WENDLANDT, Humble Oil and Refining Company, Tyler, Tex.
Panhandle	VICTOR E. COTNER, Columbian Carbon Company, Amarillo, Tex.
San Antonio	CHARLES H. ROW, Sun Oil Company, San Antonio, Tex.
Permian Basin	HAL P. BYBEE, San Angelo National Bank Building, San Angelo, Tex.
GULF COAST	SIDNEY A. JUDSON, Texas Gulf Producing Company, Houston, Tex. L. P. TEAS, Humble Oil and Refining Company, Houston, Tex.
ARKANSAS AND NORTH LOUISIANA	C. L. MOODY, Marathon Oil Company, Shreveport, La.
ROCKY MOUNTAIN	C. E. DOBBIN, 523 Customhouse Building, Denver, Colo.
CALIFORNIA	W. S. W. KEW, Standard Oil Company, Los Angeles, Calif. W. D. KLEINPELL, Box 1131, Bakersfield, Calif.
FOREIGN	
General	MARGARET C. COBB, Room 2703, 120 Broadway, New York, N. Y.
Europe and Mediterranean	W. P. HAYNES, Byron House, St. James Street, London, S.W. 1, England
Canada	THEODORE A. LINK, Imperial Oil, Ltd., Calgary, Alberta

THE BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS is published by the Association on the 15th of each month. Editorial and publication office, 505 Tulsa Building, Tulsa, Oklahoma, Post Office Box 1852. Cable address, AAPGEOL.

THE SUBSCRIPTION PRICE to non-members of the Association is $15.00 per year (separate numbers $1.50) prepaid to addresses in the United States. For addresses outside the United States, an additional charge of $0.40 is made on each subscription to cover extra wrapping and handling.

British agent: Thomas Murby & Co., 1 Fleet Lane, Ludgate Circus, London, E. C. 4.

German agent: Max Weg, Königstrasse 3, Leipzig, Germany.

CLAIMS FOR NON-RECEIPT of preceding numbers of THE BULLETIN must be sent to the business manager within three months of the date of publication in order to be filled gratis.

BACK NUMBERS OF THE BULLETIN, as available, can be ordered from Association headquarters. Cloth-bound Vol. 2(1918), $4.00; Vol. 3 (1919), $5.00; Vol. 5 (1921), $12.00; Vols. 11 (1927) to 16 (1932), inclusive, and Vol. 18 (1934), each $17.00. Other volumes, many separate numbers, and a few nearly complete sets are available. Descriptive price list sent on request. Special prices to members and associates. Discounts to libraries. Detailed *10-Volume Index* (1917–1926), $1.00. *Structure of Typical American Oil Fields*, Vols. I and II (1929), each volume $7.00 ($5.00 to members and associates). *Stratigraphy of Plains of Southern Alberta* (1931), $3.00. *Geology of California* (1933), $5.00. *Problems of Petroleum Geology* (1934), $6.00 ($5.00 to members and associates). *Geology of Natural Gas* (1935), $6.00 ($4.50 to members and associates).

THE BULLETIN furnishes thirty-five reprints of major papers. Additional reprints and covers for all or part are furnished at cost. ORDERS FOR REPRINTS should accompany corrected galley proof.

Association Headquarters—505 Tulsa Building, East Fifth Street at Cincinnati Avenue, Tulsa, Oklahoma

Communications about the Bulletin, manuscripts, editorial matters, subscriptions, special rates to public and university libraries, publications, membership, change of address, advertising rates, and other Association business should be addressed to

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, INC.

BOX 1852

TULSA, OKLAHOMA

Entered as second-class matter at the Post Office of Tulsa, Oklahoma, and at the Post Office at Menasha, Wisconsin, under the Act of March 3, 1879. Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized March 9, 1923.

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, INC.

(Organized at Tulsa, Oklahoma, February 10, 1917, as the Southwestern Association of Petroleum Geologists. Present name adopted, February 16, 1918. Incorporated in Colorado, April 23, 1924. Domesticated in Oklahoma, February 9, 1925.)

OFFICERS FOR THE YEAR ENDING MARCH, 1937

RALPH D. REED, *President*, Los Angeles, California
CARROLL E. DOBBIN, *Vice-President*, Denver Colorado,
CHAS. H. ROW, *Secretary-Treasurer*, San Antonio, Texas
L. C. SNIDER, *Editor*, New York, N. Y.

(The foregoing officers, together with the *Past-President*, A. I. LEVORSEN, Tulsa, Oklahoma, constitute the Executive Committee.)

DISTRICT REPRESENTATIVES

(Representatives' terms expire immediately after annual meetings of the years shown in parentheses)

Amarillo: J. D. Thompson, Jr. (36), Amarillo, Tex.
Appalachian: James M. Montgomery, Jr. (37), Oil City, Pa.
Canada: Theodore A. Link (37), Calgary, Canada
Capital: Arthur A. Baker (38), Washington, D. C.
Dallas: Sam M. Aronson (36), Dallas, Tex.
East Oklahoma: Ira H. Cram (37), E. F. Shea (37), C. G. Carlson (38), Tulsa, Okla.
Fort Worth: H. B. Fuqua (37), Fort Worth, Tex.
Great Lakes: Frank W. DeWolf (37), Urbana, Ill.
Houston: Kenneth Dale Owen (37), J. Brian Eby (38), Houston, Tex.
Mexico: William A. Baker (37), Tampico, Mexico
New Mexico: Neil H. Wills (37), Roswell, New Mexico
New York: R. F. Baker (37), New York, N. Y.
Pacific Coast: Roy M. Barnes (37), Louis N. Waterfall (37). Harold W. Hoots (38), Los Angeles, Calif.
Rocky Mountains: C. E. Dobbin (37), Denver, Colo.
San Antonio: Thornton Davis (37), San Antonio, Tex.
Shreveport: G. W. Schneider (37), Shreveport, La.
South America: L. W. Henry (37), Maracaibo, Venezuela
So. Permian Basin: Robert L. Cannon (37), San Angelo, Tex.
Tyler: James W. Kisling, Jr. (37), Tyler, Tex.
West Oklahoma: Gerald C. Maddox (37), Oklahoma City, Okla.
Wichita: Clare J. Stafford (37), Wichita, Kan.
Wichita Falls: J. J. Maucini (38), Wichita Falls, Tex.

DIVISION REPRESENTATIVES

Paleontology and Mineralogy
Gayle Scott (36), Fort Worth, Tex.
Maynard P. White (36), Ardmore, Okla.

Geophysics
F. M. Kannenstine (37), Houston, Tex.
George H. Westby (37), Tulsa, Okla.

PACIFIC SECTION (Chartered, March, 1925)

CHESTER CASSEL, *President*, The Texas Company, Los Angeles, California
RICHARD G. REESE, *Secretary-Treasurer*, Standard Oil Company, Los Angeles, California

Membership restricted to members of the Association in good standing, residing in Pacific Coast states. Dues: $1.50 per year

SAN ANTONIO SECTION (Chartered, April, 1929)

ADOLPH DOVRE, *President*, 710 Milam Building, San Antonio, Texas
HARRY H. NOWLAN, *Secretary-Treasurer*, 601 Milam Building, San Antonio, Texas

Membership limited to persons eligible to Association membership. Dues: $2.50. Annual meeting in October

MARACAIBO SECTION (Chartered, April, 1930)

JOHN L. KALB, *President*, Lago Petroleum Corporation, Maracaibo, Venezuela
CHESTER A. BAIRD, *Secretary-Treasurer*, Venezuela Gulf Oil Company, Maracaibo, Venezuela

DIVISION OF PALEONTOLOGY AND MINERALOGY
SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

(Organized, March, 1927; affiliated, March, 1928; chartered, technical division, April, 1930)

MERLE C. ISRAELSKY, *President*, Houston, Texas
GAYLE SCOTT, *Secretary-Treasurer*, Texas Christian University, Fort Worth, Texas

The Society issues a quarterly, the *Journal of Paleontology*, Raymond C. Moore, editor, University of Kansas, Lawrence, Kansas: subscription, $6.00. Society dues (including subscription to *Journal*), $6.00. A remission of $2.00 is allowed on dues of members or associate members of the Association. The *Journal of Sedimentary Petrology*, W. H. Twenhofel, editor, University of Wisconsin, Madison, Wisconsin, is issued three times a year: subscription, $3.00.

DIVISION OF GEOPHYSICS
SOCIETY OF PETROLEUM GEOPHYSICISTS

(Organized, 1930; affiliated, March, 1932; chartered, technical division, April, 1932)

LUDWIG W. BLAU, *President*, Houston, Texas

JOHN H. WILSON, *Secretary-Treasurer*, 610 Midland Savings Building, Denver, Colorado

The Society issues *Geophysics*, F. M. Kannenstine, editor, 2011 Esperson Building, Houston, Texas: subscription, $6.00; to A.A.P.G. members and associates, $4.00. Society dues (including *Geophysics*), $5.00.

AFFILIATED SOCIETIES

(Dates of affiliation in parentheses)

Alberta Society of Petrolum Geologists, Calgary, Alberta, Canada (31). B.L. Thorn, Secy., 503 Dept. Nat. Resources, Can. Pac. Ry.
Appalachian Geological Society, Charletson, West Virginia (31). Robert C. Lafferty, Secy., Columbian Carbon Company
Ardmore Geological Society, Ardmore, Oklahoma (36). Charles A. Milner, Jr. Secy., 102 C St., S. W.
Dallas Petroleum Geologists, Dallas, Texas (35). R. A. Stehr, Secy., Texas Seaboard Oil Company
East Texas Geological Society, Tyler, Texas (32). George W. Pirtle, Secy., Hudnall and Pirtle
Fort Worth Geological Society, Fort Worth, Texas (31). Paul C. Dean, Secy., 1818 W. T. Waggoner Buidilng
Houston Geological Society, Houston, Texas (32). O. L. Brace, Secy., 813 Second National Bank Building
Kansas Geological Society, Wichita, Kansas (31). B. S. Ridgeway, Secy., Empire Oil and Refining Co., 409 Kaufman Building
Oklahoma City Geological Society, Oklahoma City, Oklahoma (31). Henry Schweer, 2810 First National Building
Panhandle Geological Society, Amarillo, Texas (32). John E. Galley, Secy., Shell Petroleum Corporation, Box 1651
Shawnee Geological Society, Shawnee, Oklahoma (31). H. W. O'Keeffe, Secy., Phillips Petroleum Company
Shreveport Geological Society, Shreveport, Louisiana (32). Shapleigh M. Gray, Secy., The Texas Company
Tulsa Geological Society, Tulsa, Oklahoma (31). Larry D. Simmons, Secy., Oklahoma Natural Gas Building

Illustrations, courtesy of L. L. Brown Paper Company, Adams, Mass.

Rag FIBRES ARE MINIATURE CABLES!

WITH HB28 RECORDINGS YOU GET ALL-RAG BASE STOCK

Massing small wires makes the mighty cables that uphold a great bridge. Interwoven fibres of cotton and linen make strength in paper that resists the hardest usage. Haloid Record Grade HB 28 is sensitized on L. L. Brown Linen Ledger paper (100% pure white rag), whose fibres are so strong and time-resisting that the paper stands up under the roughest handling. It costs a little more than regular stock, and worth it.

DEEP BLACKS, PURE WHITES WITH HALOID RECORD PAPERS

For use where less severe demands are made upon record paper, there is Haloid Record Grade B on regular stock. The same high quality, Haloid emulsion on both papers insures brilliant contrast of dense, solid blacks and clear, snowy whites.

Prove it at our expense. Send for FREE sample roll of either Haloid Record Grade B (regular stock) or Haloid Record Grade HB 28 (L. L. Brown Linen Ledger stock), with price list and discounts.

THE HALOID COMPANY
ROCHESTER, N.Y.

Haloid RECORD

TWO SURVEYS for the price of ONE

SURWEL Clinograph operates both going in and coming out of the hole... providing a *double check*

SURWEL surveys are accurate! The instrument records observations automatically, eliminating human errors which may occur when observations are made by *sighting. SURWEL is self-checking!* It is impossible to arrive at false conclusions with SURWEL. *SURWEL saves rig time*—making the cost of a SURWEL survey lower than that of surveys made with any other instrument requiring orientation of the drill stem.

(U. S. Patents 1,124,068, 1,812, 994, 1,959,141, 1,960,038, 2,012,455, 2,012,456, and others pending.)

Sperry-Sun Well Surveying Co.

1608 Walnut Street, Philadelphia, Pa.

Tulsa Oklahoma
425 Petroleum Building

Houston, Texas
3118 Blodgett Avenue

Long Beach, Calif.
549 E. Bixby Rd.,
(3800 Block—Atlantic Ave.)

Natural Convergence of Eyes maintained by SPENCER WIDE-FIELD MICROSCOPE

Eliminates Eyestrain . . Increases Comfort

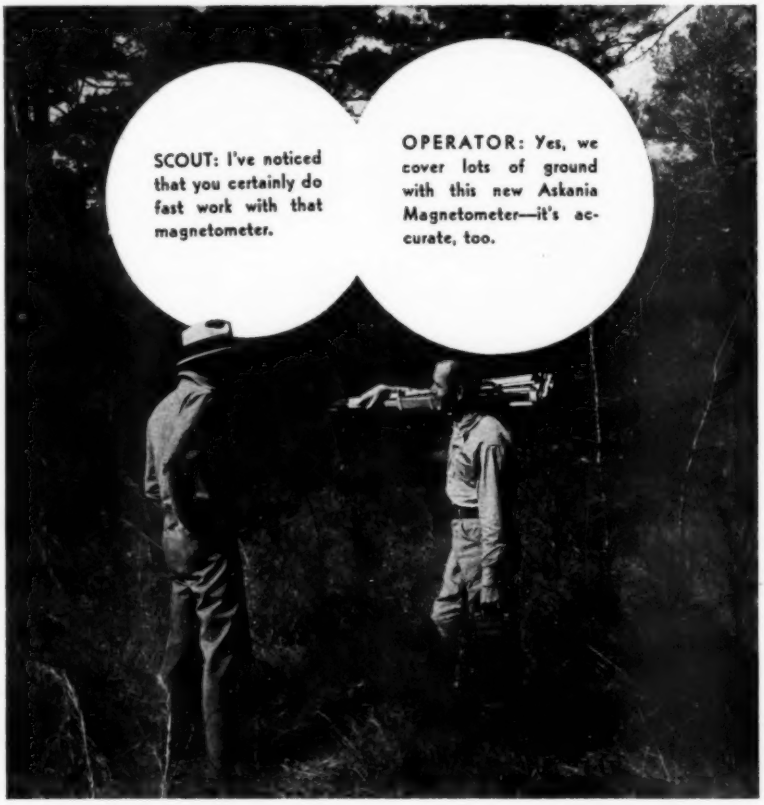
THE Spencer Wide-field Binocular Microscope is the only one in which the prisms are arranged to permit the axes of the oculars to converge at an angle of 8° which is the normal angle of convergence of the eyes at convenient reading distance.

Folder M-55 gives complete description and prices of the Spencer series of Wide-field Binocular Microscopes. We will be pleased to send you a copy.

This exclusive patented Spencer feature is one of great importance to one whose work necessitates the constant use of a wide-field microscope. The ordinary construction requires a convergent angle of the eyes of 16° which imposes an eyestrain that is excessive. The intensive eyestrain from working at this ocular convergence angle of 16° is eliminated . . and it just naturally results in protection for the eyes and increased comfort for the observer.

Spencer Lens Company

Buffalo New York


SCOUT: I've noticed that you certainly do fast work with that magnetometer.
OPERATOR: Yes, we cover lots of ground with this new Askania Magnetometer—it's accurate, too.

Speed and economy, with accuracy, are outstanding characteristics of Askania Magnetometers. That is why Magnetic surveys for reconnaissance and detail work are increasingly attracting the interest of geologists and engineers.

If your work calls for accurate magnetic prospecting, remember Askania Magnetometers. Wire, write or phone for further details, cost data, etc.

ASKANIA

AMERICAN ASKANIA
CORPORATION
825-827 M & M BLDG., HOUSTON, TEXAS

Articles for May *Bulletin*

●

Stratigraphic Versus Structural Accumulation

By A. I. Levorsen

Orange, Texas, Oil Field

By Alexander Deussen and E. W. K. Andrau

Geology and Geophysics Showing Cap Rock and Salt Overhang of High Island Dome, Galveston County, Texas

By Michel T. Halbouty

Twenty-First Annual Meeting, Minutes and Reports

BULLETIN ADVERTISERS

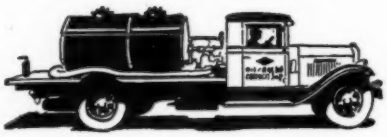
Alexander Anderson, Inc. ....
American Askania Corporation vi
American Paulin System xxi
Bausch and Lomb ....
William M. Barret, Inc. ....
Gebrüder Borntraeger xviii
Coastal Oil Finding Company xviii
Dowell Incorporated viii
Economic Geology Publishing Company xv
Geophysical Service, Inc. ....Inside back cover
Haloid Company iii
Hughes Tool Company ....Outside back cover
Independent Exploration Company xix
Journal of Geology xv
Journal of Paleontology ....
Journal of Petroleum Geophysicists ....
E. Leitz, Inc. ....
Mid-West Printing Company xv
Oil Weekly xx
Revue de Géologie xv
Schlumberger Well Surveying Corporation ....
Seismograph Service Corporation xxiii
Spencer Lens v
Sperry-Sun Well Surveying Company iv
Tulsa Chamber of Commerce xvi
Verlag für Fachliteratur ....
Western Geophysical Company ....

PROFESSIONAL CARDS

William M. Barret x
Donald C. Barton xi
Elfred Beck xi
Brokaw, Dixon & McKee ..x
D'Arcy Cashin xi
J. E. Eaton ix
Frederick G. Clapp x
Willard J. Classen ix
Richard R. Crandall ix
Ronald K. DeFord x
E. DeGolyer x
Alexander Deussen xi
David Donoghue xi
Fort Worth Laboratories ..xi
A. H. Garner x
Ginter Chemical Laboratory xi
Paul P. Goudkoff ix
C. A. Heiland ix
Hans Hlauschek x
Hudnall & Pirtle xi
Huntley & Huntley x
John S. Ivy xii
W. P. Jenny xii
E. W. Krampert xii
Laughlin-Simmons & Co. xi
George C. Matson xi
Phillip Maverick xii
C. R. McCollom ix
L. C. Morgan x
Dabney E. Petty xii
John L. Rich x
Rosaire and Kannenstine ..xii
A. T. Schwennesen xii
J. Y. Snyder x
Walter Stalder ix
Irvine E. Stewart ix
Olaf F. Sundt xii
Torsion Balance Exploration Co. xii
Harold Vance xii
G. H. Westby xi
John H. Wilson ix

GEOLOGICAL AND GEOPHYSICAL SOCIETIES

Appalachian xiv
Dallas xiv
East Texas xiv
Fort Worth xiv
Houston xiv
Kansas xiii
North Texas xiv
Oklahoma City xiii
Petroleum Geophysicists ..xiii
Rocky Mountain xiii
Shawnee xiii
Shreveport xiii
Stratigraphic xiii
Tulsa xiii
West Texas xiv



Geologists familiar with Dowell methods, equipment and personnel are among the staunchest believers in the greater safety and effectiveness of Dowell *Inhibited* Acid Treatments.

•

DOWELL INCORPORATED

Subsidiary of THE DOW CHEMICAL COMPANY

Executive Office: Midland, Michigan
General Office: Kennedy Bldg., Tulsa, Okla.

DISTRICT OFFICES

HOBBS, NEW MEXICO	SEMINOLE, OKLAHOMA	TULSA, OKLAHOMA
MIDLAND, MICHIGAN	SHELBY, MONTANA	WICHITA, KANSAS
MIDLAND, TEXAS	SHREVEPORT, LOUISIANA	WICHITA FALLS, TEXAS

DOWELL

OIL AND GAS WELL CHEMICAL SERVICE

Volume 20 Number 4

BULLETIN
of the
AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

APRIL, 1936

SYMPOSIUM ON MEXICO

FOREWORD

The San Antonio Geological Society planned to hold their Seventh Annual Meeting in Mexico City and invited the Association to join them and designate this meeting as the official Mid-Year Meeting of The American Association of Petroleum Geologists. The meeting was held October 16–20, 1935. Two hundred seventy-eight persons registered and it was estimated that three hundred fifty attended the opening session.[1]

The Geological Institute of Mexico officially acted as our hosts while in Mexico, D. F. In addition to a technical program at which a number of articles relating to the geology of Mexico were presented, there was a wide variety of entertainment, including tours, field trips, an evening orchestral concert, an afternoon concert featuring Mexican music, a reception at the home of Mr. and Mrs. Henry Norweb, a dinner-dance, and finally an excursion to Teotihuacan to attend an imposing spectacle symbolic of ancient Indian rites. This had been planned for earlier presentation but was postponed by the Governor of the Federal District in order that it might be given during our meeting and was dedicated to The American Association of Petroleum Geologists. The hospitalities and courtesies extended the visiting geologists by the geologists of the Republic of Mexico and the geologists working in Mexico for various oil companies will forever remain a pleasant memory with those who were privileged to attend.

As one result of this mid-year meeting, the executive committee of the Association decided to devote the April issue of the *Bulletin* exclusively to articles on the geology of Mexico, many of which were presented at the technical sessions in Mexico. This issue was designed particularly for the use of our members who may at some future date visit Mexico and, among other things, includes road logs from Laredo to Mexico both by way of the railroad and the automobile highway, prepared by the San Antonio Geological Society. The 1934 field trip of the San Antonio Society was also held in Mexico and the road log and map showing the route traversed and geologic formations encountered at that time are also included.

The work of assembling the material for this special number of the *Bulletin* was done chiefly by associate editor Charles H. Row of San Antonio, and William G. Kane, Saltillo, Mexico, together with Joseph M. Dawson, president of the San Antonio Section, San Antonio. These men should be remembered gratefully by those who may use this *Bulletin* in future years.

A. I. LEVORSEN

[1] For description of the meeting, see the *Bulletin*, Vol. 19, No. 12 (December, 1935) pp. 1835–40.

Vertical aerial photograph of Rancherias gas field, near Camargo, state of Tamaulipas, Mexico, showing bevelled edges of formations outlining anticlinal structure. Photograph taken before discovery of gas. Field now has three gas wells. Rio San Juan (right side of photograph) flows north into Rio Grande (north side of photograph). Scale: 1 inch = 1 mile. By permission of Edgar Tobin Aerial Surveys, San Antonio, Texas.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 20, NO. 4 (APRIL 1936), PP. 387-393, 1 FIG.

PETROLEUM GEOLOGY AND THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS[1]

A. IRVING LEVORSEN[2]
Tulsa, Oklahoma

Mr. Chairman, Ladies and Gentlemen:

Meeting here in Mexico, as we are, where it would seem even to the casual observer that future petroleum discoveries may far exceed those of the past, it may be appropriate very briefly to tell something of the position which petroleum geology has gained for itself in the oil industry, particularly in the United States, in the short time within which it has been applied; also to tell something of the organization and the activities of The American Association of Petroleum Geologists. This is with the thought that it may encourage those here charged with the discovery and development of the oil and gas resources of Mexico to make the fullest use of this comparatively new, yet extremely helpful science, and also that it might give those of our members who have come here a better idea of what is going on in the Association.

The science of geology probably began during the eighteenth century and it was not until 1859, when the first oil well was drilled in the United States, that geologists began to correlate the occurrence of oil with geological phenomena. During the succeeding 60 years there was published a considerable geologic literature on the relation of geology to oil and gas but during the decade between 1910 and 1920 petroleum geology and the petroleum geologist really began to come into their own. The 25 years since 1910 have seen the uses of geology and its allied sciences expand until today the exploration for oil and gas by all of the modern oil companies is almost entirely under geologic supervision. Many of our present-day oil-company geological organizations are complex and composed of a wide variety of specialists working in highly restricted fields. This is a gradual evolution from the earlier, more general character of geologic work.

The anticlinal theory as worded by I. C. White in 1885, which explains the occurrence of oil and gas in anticlines as due to differences in specific gravity, has been the background of our application of

[1] Address at the mid-year meeting of the Association with the seventh annual field trip of the San Antonio Geological Society, at the Palace of Fine Arts, Mexico City, October 16, 1935.

[2] President of the Association.

geology to the problem of oil-finding and is as sound today as it was when first proposed. The early efforts of the petroleum geologists were therefore chiefly in the search for anticlines and domes by surface geological mapping. Later, as more wells were drilled, many geologists became specialists in working with subsurface or underground information. Others specialized in core drilling for anticlines and developed a technique of shallow drilling and correlation in areas which could not be mapped otherwise, resulting in the discovery of many new oil fields and much new information. With the increased use of the rotary drill, a need was felt for accurate knowledge of formations penetrated, and the microscopic examination of well cuttings, sampling of wells, and micropaleontology required the services of a large number of geologists. Geophysics—which invokes a wide variety of physical laws to assist in deciphering the underground geology in advance of drilling—came into prominence in 1924 with the discoveries through it of buried salt-dome structures and oil fields on the Gulf Coast. Geophysical methods spread like wild-fire to all the possible oil-bearing areas and in places the accuracy of the predictions was almost uncanny. At present 15 million or more dollars a year are being spent on geophysics alone—chiefly on seismic exploration—an expenditure which gives an idea of its importance in the eyes of the industry. The record of oil discovery through geophysical methods is a brilliant one, and even a fraction of the past rate of development of these methods, if applied to the future, foretells results beyond anything which we might now dream.

It is true that much oil and many oil fields have been discovered in the United States without the aid of the geologist. This has been particularly true in those provinces where many pools of the sand-lens type exist and where unforeseen sand conditions, overlap, and variable porosity are important factors. However, the success of the geologist employing geological methods has been substantial and many pools and much oil have been discovered directly or indirectly by geological methods. Some of the outstanding oil pools which have been discovered in recent years, either wholly or in part as a result of the application of geology to the problem, include Garber, Tonkawa, Seminole, Oklahoma City, and Edmond in Oklahoma; Yates, Van, Salt Flat, Luling, Mexia, Powell, and the Panhandle in Texas; many salt domes along the Gulf Coast in Texas and Louisiana; Kettleman Hills and others in California; and many lesser pools in Michigan, Kansas, New Mexico, and the Rocky Mountain states.

Our next forward step, in my opinion, is for the geologist, the geophysicist, and the stratigrapher to get together and develop a tech-

nique which will enable them to locate pools of the overlap or sand-lens type, such as the East Texas, Burbank, and similar pools. Heretofore, practically all of our geologic work has been directed toward the search for anticlines and domes and we have more or less ignored the fact that a large percentage of the oil which has been produced in the past has come from pools more closely related to stratigraphic variation than to pure structural anomalies. In other words, there may come an end some day to favorable local structure, but that should not mean an end to oil reserves.

In the short space of 25 years the petroleum geologist has advanced in the regard of the industry from the position of a novice or meddler to that of an indispensable factor in the search for, and the development of, the oil deposits. There is now scarcely a lease that is bought, a well that is drilled, or a development program planned without the recommendation and advice of a geologist. The executives of practically every large oil company in the United States are geology-conscious and understand in a large measure the fundamental principles and theories which the petroleum geologist uses. The responsibility for oil discovery and exploration is more and more resting on the geologist and the tools with which he works. The geologist is accepting this responsibility, and in doing so, is continually and seriously studying, experimenting, and classifying, knowing that the problem of oil-finding is one which is subject to a scientific approach and that the greater our scientific knowledge the more useful we are, both to the industry and to the public of which we are a part.

In the United States, petroleum geologists and The American Association of Petroleum Geologists are practically synonymous terms. Probably one of the most significant meetings of geologists engaged in petroleum geology was held 20 years ago this month in Tulsa, Oklahoma, when 27 geologists met at the call of J. Elmer Thomas and decided that an association should be organized. At the third meeting, in 1918, the name was changed from the Southwestern Association to The American Association of Petroleum Geologists with a total membership of 177. A steady growth in membership followed until a peak of 2,562 was reached in March, 1931. The depression years levied a heavy toll and at the beginning of 1935 we had less than 2,000 members. However, our membership is now on the increase and at present we have 2,134 members and associates. Of these, 26 live in Mexico, 222 in other countries outside the United States, and 1,886 in the United States.

The object of The American Association of Petroleum Geologists, according to its Constitution, is

. . . to promote the science of geology, especially as it relates to petroleum and natural gas; to promote the technology of petroleum and natural gas . . . ; to foster the spirit of scientific research among its members; to disseminate facts relating to geology and natural gas; to maintain a high standard of professional conduct on the part of its members; and to protect the public from the work of inadequately trained and unscrupulous persons posing as petroleum geologists.

In furthering these objectives, we publish a monthly *Bulletin* which contains 100–130 pages of articles on the application of geology to petroleum and natural gas. In addition to the *Bulletin*, we publish from time to time special volumes on related subjects pertaining to oil and gas and there are at present 7 books in this group. The most recent of these was published the past summer and is entitled, *The Geology of Natural Gas*. It contains 1,200 pages written by 47 of our members and describes the occurrence and geology of all the important gas deposits on the North American continent. One article written by John M. Muir is on the occurrence of natural gas in the Republic of Mexico. Mr. Muir has also written a volume which will soon go to the printer and which should be ready for distribution by next March. The title is *The Geology of the Tampico Embayment, Mexico*, and it promises to be one of the finest books we have published and a real contribution to the geologic literature of Mexico. Another book in the making is *Gulf Coast Oil Fields*, of which Donald C. Barton and George Sawtelle are the editors. It will include a large number of articles by many authors dealing with Gulf Coast geology and it is hoped that it will be published some time in 1936. A *Comprehensive Index* to all Association publications is now in the planning stage and it is hoped that it also may be ready in 1936.

A 5-room headquarters office with a staff of four employees is maintained at Tulsa under the direction of J. P. D. Hull, the business manager of the Association. There the business of editing and publishing is transacted and membership files and records are kept. We have an active research committee under the chairmanship of Donald C. Barton. We also have a committee on applications of petroleum geology under Frank R. Clark's direction, the purpose of which is to aid in giving the public an understanding of geology and of the ways in which geology can be applied. Each year in March we hold a 3-day convention at which time many articles on geology and its application to the oil and gas industry are presented and where much discussion and interchange of ideas broaden the interest and understanding of every attending member. These articles furnish much of the material which is later published in the *Bulletin*. Our next annual meeting is to be held in Tulsa, Oklahoma, on March 19–21, 1936, and we

earnestly hope that many of our members and others living in Mexico will be able to attend.

Two groups of our specialized workers have formed separate but affiliated divisions. One of these is the Division of Paleontology and Mineralogy, composed of those of our members whose work is chiefly in the field of paleontology and microscopic sample examination. This division publishes semi-quarterly the *Journal of Paleontology* and quarterly the *Journal of Sedimentary Petrology*. The Division of Geophysics includes those members engaged chiefly in geophysical methods of prospecting. They have this Fall made their initial effort at a separate publication—the *Journal of Geophysics*—and their plans are to publish this Journal containing articles on geophysics twice a year.

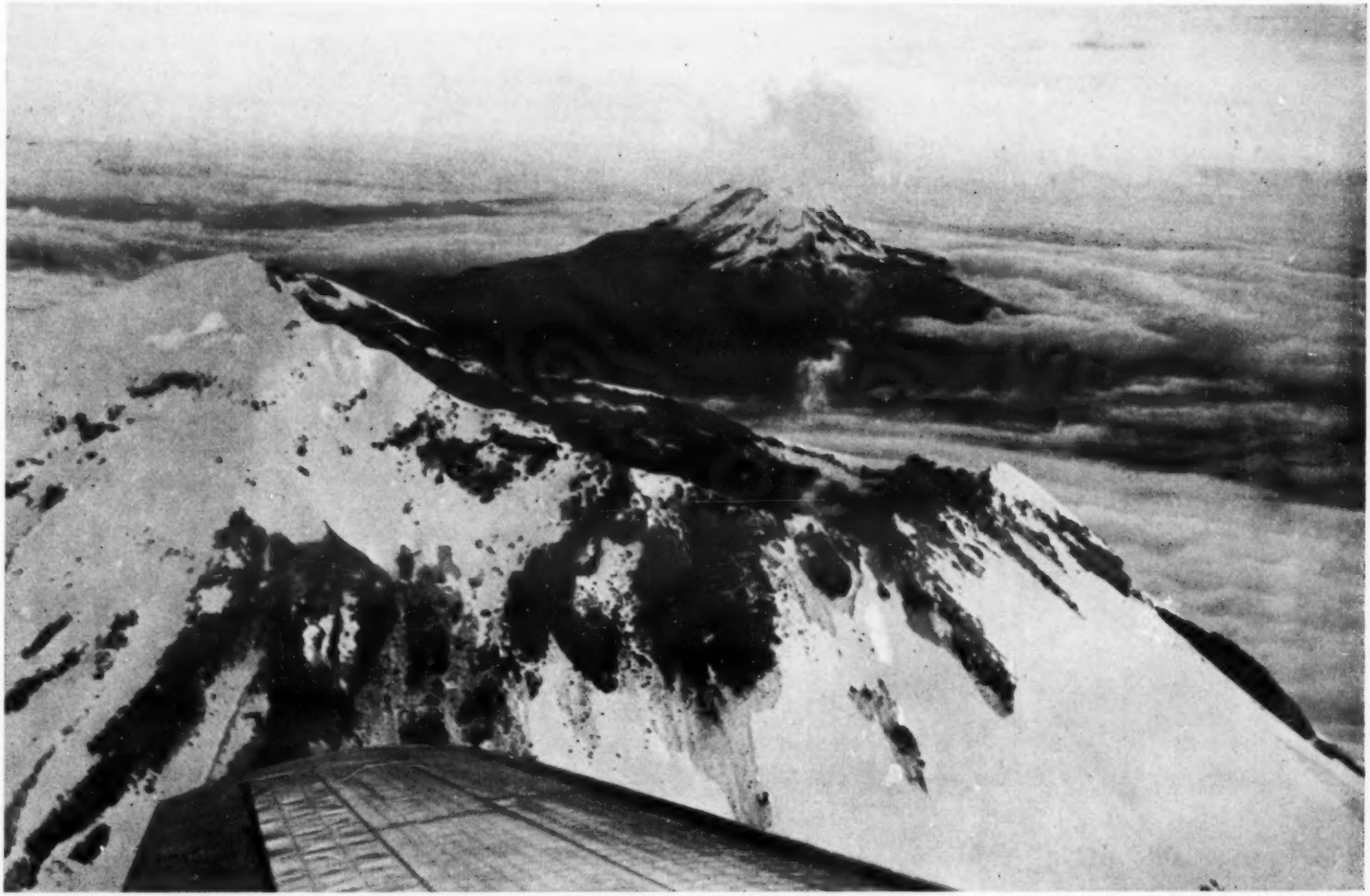
Affiliated with the Association or as Sections of it are 16 groups of geologists located in the various oil-field centers of the United States and one at Maracaibo, Venezuela. These are the local societies of which the San Antonio Section is typical. There are several with memberships of more than 150. They hold weekly, semi-monthly, or monthly meetings and are to the local area what the Association is to the industry as a whole. Many of the local societies hold annual field conferences lasting from 1 to 10 days, during which time places of geologic interest are visited and discussed on the ground. This Fall, for example, the Kansas Geological Society held a 10-day field conference through the upper Mississippi Valley in Iowa, Illinois, Wisconsin, and Minnesota; the Panhandle Geological Society, of Amarillo, conducted a 2-day field trip into the Las Vegas, New Mexico, region; the Shreveport Geological Society sponsored a 2-day field trip into the Ouachita Mountains of Oklahoma; and, as you know, we are in attendance of the Seventh Annual Field Conference of the San Antonio Section. These field trips are of tremendous value to the geologists who attend, in that they furnish a splendid opportunity for an exchange of information and ideas. They are being supported more and more by the oil companies and many companies send several representatives.

I doubt if there is any group of professional or scientific men who are more sincere or more earnest in their efforts to apply their science to an industry. The oil industry is moving forward at a rapid rate, but I believe that we geologists are keeping pace with it and are doing our part. This desire to learn is the reason we are here. We are learning, in this splendid geological program, in the drive across Mexico, and in our visits with the Mexican geologists, something of the geology of Mexico and of these great Mexican oil fields, and we are learning it from those whose experience was won under the most difficult of

physical conditions and who are today the real pioneers of our profession. Also—perhaps no less important—we are more aware of the enormous possibilities for new oil fields which are yet to be discovered in Mexico and to which I am sure geology and geologists will continue to contribute their part.

For a number of years there has been an insistent demand from many of our members to hold a meeting in Mexico City. Therefore, when the San Antonio Geological Society, together with the geologists of Mexico, so generously invited us to designate this meeting as the Mid-Year meeting of the Association, your executive committee lost no time in doing so. And I am glad to say that we are very much pleased with the program and with the arrangements.

Permit me, therefore, to express the deep gratitude of The American Association of Petróleum Geologists to the Geological Institute of Mexico and to the San Antonio Geological Society for giving us this marvelous meeting. We are particularly grateful to Sr. Cosme Hinojosa, Governor of the Federal District, for his cordial welcome to Mexico City, to Sr. Aguilera, former director of the Institute and dean of Mexican geologists; to Sr. Santillán, Sub-Secretary of National Economy and present director of the Institute, for presiding at our meeting and for giving his most interesting talk this morning on the geology of Mexico; and to Sr. Ordoñez, loved by all who know him, and to whom, probably above all others, is due the success of our meeting. The sight-seeing trips; the symphonic orchestral concert to be given this evening through the courtesy of the Minister of National Economy; the extreme generosity of the Governor of the Federal District in postponing the Indian ceremonial for our benefit until next Sunday; all make this seem more like a fairy tale than a geological meeting. And through it all let us not forget that the enthusiasm of Joe Dawson, Bill Baker, Bill Kane, and Thornton Davis has kept the plans always going forward. We are indeed grateful for this unforgettable experience of learning of Mexico, its geology, its history, its beautiful scenery, and its charming people.



View across crater of Mount Popocatepetl looking north toward Mount Iztaccihuatl, both snow capped. Sulphurous fumes are rising from Popocatepetl, not from Iztaccihuatl. Photograph taken by A. I. Levorsen at 7:00 A.M., October 17, 1935, from airplane at elevation approximately 18,000 feet (elevation of "Popo" 17,794 feet above sea-level). Banks of clouds cover Valley of Mexico, 10,300 feet lower.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 20, NO. 4 (APRIL, 1936), PP. 394-402

SYNOPSIS OF THE GEOLOGY OF MEXICO[1]

MANUEL SANTILLÁN[2]
Mexico, D.F.

ABSTRACT

Mexico is divided into five physiographic provinces and a generalized description is given of the lithologic character of each of these provinces. A synopsis is given of the formations representing the Proterozoic, Mesozoic, and Cenozoic eras and their component periods. Brief mention is made of some type fossils found and of the economic importance of certain parts of the section.

The Mexican territory is composed of the five following physiographic elements: (1) Central Plateau, (2) Western Sierra Madre, (3) Eastern Sierra Madre, (4) Yucatán Peninsula, (5) Lower California Peninsula.

The broad Central Plateau known as the Mesa Central has an altitude varying from 1,200 to 2,600 meters above sea-level. Beginning in the state of Chihuahua on the frontier with the United States, this great Central Plateau extends southward through Coahuila, Durango, Zacatecas, and San Luis Potosí. The southern end of this plateau area becomes mountainous and in the states of Aguascalientes, Guanajuato, Querétaro, and México, isolated ranges rising from the plains become more and more lofty, some of them reaching elevations of 600 meters above the Central Plateau area. The fertility of some of the valleys found between these mountain ranges is notable. Iguala, Amacuzac, and Apatzingán are examples of such rich agricultural valleys. Most of them are filled in with Quaternary sediments derived largely from the disintegration of the igneous and sedimentary rocks of the near-by mountains.

The Western Sierra Madre physiographic province lies along the western margin of the Mesa Central. It is the southern extension of the great American Cordillera. It occupies most of the territory in the western states of the Republic of México from Sonora down to the 20th parallel, where it turns southeast through the states of Michoacán, México, and Morelos. Farther extensions of these same ranges are the Sierra Madre del Sur in the states of Guerrero and Oaxaca. This province is characterized mainly by extremely rough mountainous country with only relatively few narrow strips of the coastal plain

[1] Read before the Association at the mid-year meeting, Mexico City, October 16, 1935. Manuscript received, October 30, 1935.

[2] Director of the Mexican Geological Survey.

along the Pacific Ocean. In many places, this physiographic province is found to terminate abruptly as the mountains come down to the sea.

The Eastern Sierra Madre lies along the eastern margin of the Mesa Central. This great mountain system extends southward from Coahuila through Nuevo León, Tamaulipas, and Veracruz, meeting the south extension of the Western Sierra Madre in the state of Oaxaca in the region known as the "Nudo del Zempoaltēpetl." Although the mountains of the Eastern Sierra Madre terminate somewhat abruptly along their eastern margin, extensive coastal-plain areas are found between them and the Gulf of México.

The Yucatán Peninsula, which comprises the states of Campeche, Yucatán, and the territory of Quintana Roo, has very little relief and forms an extensive plain which has a slight inclination toward the north.

The peninsula of Lower California comprises physiographically a mountain range trending northwest and southeast in the form of a backbone, dividing the watersheds of the Gulf of California on the east and the Pacific Ocean on the west. On both sides of the peninsula are somewhat extensive plains. These sparsely inhabited, semi-arid lowlands have many desert characteristics and in many places they are terminated by cliffs along the coast.

The physiographic provinces already described contain a great variety of sedimentary, metamorphic, and igneous rocks. The mountain ranges of the Western Sierra Madre contain some exposures of Mesozoic and even a few areas of Paleozoic sedimentary rocks. These rocks have been metamorphosed in many places by intrusions of granites, monzonites, syenites, and diorites. The larger part of this province, however, is covered by igneous rocks of the effusive type which are Tertiary and post-Tertiary in age. Andesites, rhyolites, dacites, basalts, tuffs, and breccias are common in most of the territory on the Pacific slope.

Most of the Mesa Central, on the other hand, is composed of Mesozoic and some Paleozoic sedimentary rocks in the mountains and extensive Quaternary gravels and isolated effusive igneous rocks in the valleys.

The mountains of the Eastern Sierra Madre are composed principally of limestones and shales of Cretaceous age, but there are several areas of Paleozoic sedimentary rocks exposed in the more deeply eroded areas. In some places these sediments contain intrusive masses, but flows of effusive rocks within these mountains are relatively scarce. There are, however, numerous volcanic plugs and lava

flows at the south end of the Gulf Coastal Plain along the east front of the Eastern Sierra Madre. Tertiary sediments ranging from the Eocene to the Recent have been well developed along the Gulf Coastal Plain, especially at its northern end. Here, Upper Cretaceous sediments are also found along the east flank of the Eastern Sierra Madre.

The Yucatán Peninsula is characterized by sedimentary rocks of Tertiary-to-Recent age. Though no igneous rocks of any kind are known in the Yucatán Peninsula, the Lower California Peninsula is almost entirely covered with intrusive and effusive rocks of Tertiary and post-Tertiary age that have been brought up through Cretaceous and Tertiary sedimentary rocks.

The following is a brief synopsis of such of the geologic eras and their component periods as are represented by lithologic units in México.

PROTEROZOIC ERA

The oldest rocks known in México are some of those found in the Western Sierra Madre that belong to the Proterozoic era. Localities in which erosion has uncovered beds of this era are found in the states of Sonora, Sinaloa, Durango, Chihuahua, Jalisco, Colima, Michoacán, Guerrero, Oaxaca, and Chiapas. In the interior of the country, formations of the same age have been found in Puebla, Hidalgo, México, Morelos, Guanajuato, and Zacatecas. These rocks are igneous and metamorphic. The igneous rocks include granites, pegmatites, and diorites. Among the metamorphic rocks are crystalline schists, micaceous slates, chloritic slates, sericitic slates, and biotitic porphyritic gneisses which are easily exfoliated and rarely become muscovitic gneisses. These rocks are intruded by the aforementioned igneous rocks, and as a result of lateral compression have been folded and faulted, forming many series of synclines and anticlines with axes striking in different directions.

PALEOZOIC ERA

Paleozoic rocks are limited in extent, have been found only in small areas, and represent different periods of this era. Sedimentary rocks predominate over the igneous rocks.

Cambrian.—In different parts of Sonora and Sinaloa there have been found very coarse-grained crystalline limestones with abundant chert concretions which are overlain by quartzitic sandstones and schists. As these rocks do not contain fossils, their exact age is indeterminate, but they have been assigned to the Cambrian because of their lithologic similarity to Cambrian rocks in other countries.

Silurian.—In very small areas of México, rocks of Silurian age have been identified by their megascopic fauna which include heliolites and encrinites. These fossils are very scarce in the limestones and quartzites in which they occur.

Devonian.—The existence of Devonian is problematic in México. Some of the slates, quartzites, and limestones found in the states of Sinaloa and Chiapas, though they do not contain Devonian fossils, have certain lithologic characteristics which are very similar to those of Devonian rocks in other places.

Mississippian and Pennsylvanian.—Although Mississippian and Pennsylvanian rocks have been found in only a few small areas in the Eastern Sierra Madre, they have a very good fauna definitely fixing their age in the area west of Victoria, Tamaulipas. Brachiopods, crinoids, corals, and other Lower Carboniferous fossils are also found in the limestones, dolomites, sandstones, and slates in Chiapas and southward into Guatemala.

Permian.—In the Sierra del Sobaco on the Hacienda de Las Delicias in the state of Coahuila, small areas of Permian outcrops have been discovered. This section of more than 5,000 feet of beds is composed of a lower sandy series of volcanic origin and an upper series of fossiliferous black limestones and shales. Many typical Permian forms of *Fusulina*, *Productus*, *Spirifer*, coral, and other fossils have been collected from these beds.

MESOZOIC ERA

Though Mesozoic sediments were probably deposited over almost all of the area of México, they are not now nearly as much in evidence on the western slope as they are on the Central Plateau and the east slopes. Only in isolated areas are these beds left uncovered by the great volcanic deposits that affected the whole Pacific coastal area in Tertiary and post-Tertiary time.

Though all of the three subdivisions of the Mesozoic era are represented, the Triassic and Jurassic beds are found only in relatively small areas. The Cretaceous series, on the other hand, is one of the most widespread in México. It includes the formations constituting two of the three major physiographic provinces. Aside from its orogenic importance, it is of great economic importance. Most of the petroliferous beds and many of the mineral-producing horizons are Cretaceous in age.

Triassic.—In various parts of the Western Sierra Madre and in isolated outcrops in some of the central states, Triassic sedimentary rocks have been exposed by erosion. Generally these sediments are

composed of black, gray, yellowish, and red shales with conglomerate and sandstones. The shales have been greatly affected by tectonic forces, producing complicated faults, fractures, et cetera. Triassic sediments are found in the Sonora Mountains at La Barranca, San José de Pimas, San Marcial, Moradillas, El Lápiz, and Los Bronces, and consist of shales, gray and reddish sandstones, red conglomerates, and schists varying in color from black to gray. Their age could be referred to the Upper Triassic, as their principal fossils are *Annodontophora sonorensis* and *A. mexicana*. The shales show very remarkable metamorphism, especially those of high-silica content which have been transformed into siliceous slates and quartzites. At Los Bronces the Upper Triassic contains a well preserved fossil flora. On the boundary of the states of Oaxaca and Puebla there are some Triassic formations identical with those of Sonora, containing the same fossil flora. Upper Triassic sediments are also found at the following places: La Trinidad, Ahuacatlán, Teocamatlán, Olomatlán, Yetla, Teozatlán, Santa María, San Andrés Yucunuti, and Mixtepec. In the central part of Zacatecas and the southern part of Coahuila is a series of black schists, greenish sandstones, and gray slates interbedded with quartzites of marine origin and alternating with diabase and tuffs. These beds are thought to be Upper Triassic in age as they contain characteristic Carnian fossils, found in La Pimienta Creek near the City of Zacatecas.

Jurassic.—Lower, Middle and Upper Jurassic are all represented in México, although none of them exhibits a complete section. The areas where the rocks of this period are found are widely separated and form parts of the mountainous masses in the western, southern, and central parts of the Republic. The Lower Jurassic is found in some isolated outcrops in the states of Hidalgo, Oaxaca, Puebla, Sonora, and Veracruz. The formations of the Lower Jurassic are shales containing an abundant Liassic flora, composed mainly of remains of *Cicadea*. In the vicinity of the village of Huauchinango, Puebla, the Lower Jurassic shales are carbonaceous and their colors are black, gray, reddish gray, or yellowish. In the former districts of Magdalena and Altar, state of Sonora, the Jurassic formations are shale interbedded with thin sandstone layers. At Las Animas are Lower Jurassic limestones identified through their fauna of bryozoans and gastropods. Lower Jurassic rocks also occur in the Sierra Caracahui and at El Lápiz. At Huayacocotla, Veracruz, the Lower Jurassic shales have been much altered, faulted, and folded by very intense tectonic movements. The Jurassic formations at the Vinazco River, between El Zopilote and El Durazno creeks, are remarkable for their well preserved fossil plants.

The Middle Jurassic has not been identified except in the vicinity of Cualac, Guerrero, and in a very small area of Oaxaca. It consists of limestones and dark marls containing brachiopods and bivalves. At Oaxaca, near San Juan Diquiyú, El Carrizo, and San Andrés, and in the vicinity of Tlaxiaco are some shales which contain iron nodules and some carbonaceous layers that are probably Middle Jurassic in age.

The Upper Jurassic is of wider distribution and of greater interest. It is found in the states of Coahuila, Nuevo León, San Luis Potosí, Puebla, and Veracruz, in the Eastern Sierra Madre; in Chihuahua, Sonora, and Oaxaca on the Pacific slope, and in Zacatecas in the central part of the Republic. In the central part of México a complete section of the Upper Jurassic beds shows at least twelve divisions with distinctly different fossil fauna. In the Sierra de Catorce, San Luis Potosí, the beds of this age are sandstones and marly slates. In the Sierras de Santa Rosa and San José, of the mineral district of Mazapil and Concepción del Oro, northern Zacatecas, the Upper Jurassic section is composed of compact gray limestones containing an abundance of *Nerinea* interbedded with gray marls and coral beds containing remains of poorly preserved gastropods and bivalves. In the same state, in the canyons of San Matías, Puerto Blanco, Chorreadero and El Aire, the Upper Jurassic stratified beds have a thickness varying from 15 to 30 meters. In the state of Durango at San Pedro del Gallo, sandstones, white quartzites, and marly slates of Upper Jurassic age are observed. The Upper Jurassic is also found at Santo Domingo, Cuchillo Parado, Placer de Guadalupe and Lluvia de Oro, Chihuahua; Canyon del Chueco, in Mier y Noriega, near Aramberri, Nuevo León; Tlaxiaco, Oaxaca; San José Chapultepec, Tutotepec, and Ometepec, Puebla.

Cretaceous.—With very few exceptions in almost all of the states of the Republic the Cretaceous is represented by one or more of its three subdivisions. Cretaceous rocks, mostly of marine origin, form almost all of the isolated mountain range on the broad Central Plateau. They make up almost all of the Eastern Sierra Madre, and nearly half of southern México is covered with outcrops of Cretaceous beds.

Lower Cretaceous.—Lower Cretaceous formations are generally interstratified with intrusive rocks. In some places they are found lying on Upper Jurassic beds and in isolated areas they were deposited upon a basement of Paleozoic rocks. The Lower Cretaceous section is composed of well stratified gray-to-yellowish gray limestones, yellowish-to-gray marls, gray-black and reddish shales and a few marly and calcareous sandstones. An abundant fauna, including

ammonites, monopleura, and belemnites, is found in these beds wherever they are exposed. Extensive outcrops of these beds are found at San Pedro del Gallo, in Durango; Mazapil and Santa Rosa, in Zacatecas; Tlaxiaco, in Oaxaca; Sierra de Catorce, in San Luis Potosí; Zapotitlán, in Puebla; Cualac, in Guerrero; La Parota, in Michiocán; Necoxtla, in Veracruz; and in many parts of the states of Colima, Jalisco, and Sonora.

Middle Cretaceous.—The great limestone section of Middle Cretaceous age has one of the most widespread distributions in México. Though only isolated areas of it remain exposed in the states along the Pacific coast, the larger part of the Central Plateau and Eastern Sierra Madre is covered by the outcrops of these beds. Almost all of the mountains that rise above the great Central Plateau are of Cretaceous limestone and in the Eastern Sierra Madre these beds have been folded into lofty sierras many of which are 3,500 meters above sea-level.

Dark gray-to-black limestones, marly limestones, and a few interbedded calcareous shales make up most of this great section of marine sediments. It is highly fossiliferous throughout, *Rudistes Ostrea*, *Nerinea*, and *Caprina* being found in great abundance.

These beds have usually been subjected to profound folding and in places faulting. The distortion and fracturing accompanying this severe folding left ample opportunity for solution of the limestones by circulating ground waters. These processes have caused the economic importance of the Middle Cretaceous beds in México. Numerous areas have been enriched by silver, lead, zinc, and copper deposits formed in connection with solution and replacement of these limestones. On the other hand, induced porosity created in this way has been thought to be of primary importance in the accumulation of the rich oil fields of the Tampico and Túxpan areas.

Upper Cretaceous.—The most widespread occurrence of Upper Cretaceous rocks in México is found in the northern states of Chihuahua, Coahuila, Nuevo León, Zacatecas, and Lower California. Great thicknesses of interbedded dark shales with interbedded sandstones and calcareous and marly shales characterize this series of sediments on the eastern side of the Central Plateau. Fossil remains found in these beds include ammonites, fishes, *Nerinea* and *Ostrea*. These beds are chiefly valuable economically for the large coal deposits in the Sabinas basin in northern Coahuila.

CENOZOIC ERA

Cenozoic rocks, both igneous and sedimentary, are widely distributed in all the states of México and are of great interest, not only

geologically, but for their mineral and petroliferous richness. The igneous rocks may be subdivided into intrusive, extrusive, and pyroclastics. The intrusives, found mainly in the Mexican Sierras Madres, include granites, granodiorites, monzonites, syenites, and diabases. Among the extrusive igneous rocks found in the same regions are andesites, rhyolites, basalts, retinites, taquilites, obsidians. The pyroclastics are mainly tuffs, ashes, and andesitic, rhyolitic, and basaltic breccia. The sedimentary formations include marine limestones and marls, lagoonal clay and marly limestones, as well as sandstones, conglomerates, and volcanic products accumulated under water.

Eocene.—Although there are some Eocene beds in Chiapas and in Lower California, the section is best developed along the coast of the Gulf of México and in the states of Nuevo León, Tamaulipas, and Veracruz. Great thicknesses of interbedded marine shales and massive sandstones are characteristic of these beds in northeastern México. A rich variety of both microscopic and megascopic fossils is found in the formations of the Eocene. *Ostrea*, *Natica*, *Turritella*, *Cerithium*, *Venericardia*, *Volutocorbis*, *Pteropsis*, and many others are found in great abundance in these beds.

The Eocene of northeastern México appears to have some very promising economic possibilities. Already commercial gas fields have been developed at La Presa and Rancherías in northern Tamaulipas, and it is believed that the lower Jackson or Yegua beds have excellent possibilities for oil production in this area.

Oligocene.—The upper and lower parts of these beds are known as the Alazán and Mesón formations, respectively, in the oil fields of northern Veracruz and Tamaulipas. These beds have been recognized on subsurface paleontologic evidence from cuttings of wells drilled in the Gulf Coastal Plain. They are largely composed of sandy marls with here and there thin layers of interbedded sandstone.

Miocene.—Formations of Miocene age have been identified in Lower California, Chiapas, Hidalgo, along the Gulf coast, and in the Isthmus of Tehuantepec. They are composed of argillaceous sands and grayish-to-whitish limestones. Fossils found in these beds are not very well preserved and have not been identified.

Pliocene.—Pliocene rocks are very extensive in the states of Chiapas, and Oaxaca, and in certain places of Lower California. The Yucatán Pliocene occupies more than half of the northern part of the peninsula and is composed of fossiliferous limestones. In the state of Veracruz at Acayucan, Papantla, Túxpan, and Santa Rosa the Pliocene is represented by gray sand and fossiliferous blue marls containing *Sigaretus* and *Turritella*.

After the close of the Cretaceous period, great folding weakened

the earth's crust along the axes of the anticlines and synclines, and made them lines of lesser resistance. Later, during the Miocene and Pliocene periods, these weakened areas were invaded by the great molten masses and used as channels for these great lava flows to the surface. In these mountains of the central and southern ranges, are andesites and rhyolites with their corresponding tuffs. The manifestations of the Tertiary vulcanism are shown not only by the eruption of lavas through great crevices, but also through volcanic cones of great size, for example, the Pico de Orizaba, Cofre de Perote, Popocatepetl, Ixtaccihuatl, Ajusco, Nevados de Colima and Toluca. The summits of these peaks rise to such heights as to leave them covered with perpetual snow.

Quaternary.—The Quaternary formations are widely distributed in the valleys and along the coasts. The sedimentary rocks are mostly alluvium of clays, marls, and sands, and the igneous rocks include tuffs, ash, and other volcanic rocks. In the sedimentary beds mammal remains have been discovered, including *Ursus*, *Elephas*, *Equus*, and *Cervus*. Quaternary basalts, tuffs, breccia, and basaltic glasses cover extensive areas in many regions. Some of these volcanic eruptions occurred within the historical period. Lavas exuding from the volcanoes, flowing down to the lower areas, encountered inhabited places, destroying and burying them. Such is the history of the small volcano, Xictli, in the Ajusco Sierra near Mexico City. Human remains can be seen buried beneath the lava that came from this volcano.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 20, NO. 4 (APRIL, 1936), PP. 403-416, 2 FIGS.

STRUCTURAL GEOLOGY OF BORDER PROVINCE OF NORTHEASTERN MEXICO ADJACENT TO ZAPATA AND STARR COUNTIES, TEXAS[1]

WILLIAM G. KANE[2]
Saltillo, Coahuila, Mexico

ABSTRACT

The major structural features of the Eocene beds are shown in a way that enables the reader to get a fair idea of their relative size and significance. The several important anticlines, synclines, and fault zones are described, and a suggestion is made of a possibility of cross-folding influences from central Coahuila being projected eastward into the Gulf Coastal Plain of northern Mexico and South Texas.

INTRODUCTION

The area under consideration in this paper has received much detailed study during the past 10 years by the geologists of many oil companies operating in Mexico, but it has not been until the last few years that geologists working in South Texas have taken an interest in it. Extending from the Laredo-to-Monterrey highway on the north to a line between China, Nuevo Leon, Mexico, and the Sam Fordyce field, Hidalgo County, Texas, on the south, the map of this area is intended to show all of the most important structural features. An attempt has been made to present these features in approximately their true dimensions so that the relative importance of the several structural elements can be studied in relation to each other and inference may be drawn regarding the probabilities of their significance to adjacent areas. The sector embraced within this area is approximately 50 miles wide and more than 100 miles long.

The ideas advanced in this paper are predicated on a knowledge of this area gained by plane-table mapping of almost half of it and a rather intensive reconnaissance of the rest of it. Special credit is due to Arthur H. Petsch and to his assistant, J. Sherman Leonard, for much of the detail work in the field, and the writer is indebted to the management of the Ohio-Mexico Oil Corporation for permission to publish this work.

The only work in the geologic literature to date that deals with

[1] Read before the Association at Mexico City, October 17, 1935. Manuscript received, January 28, 1936.

[2] Chief geologist, Ohio-Mexico Oil Corporation.

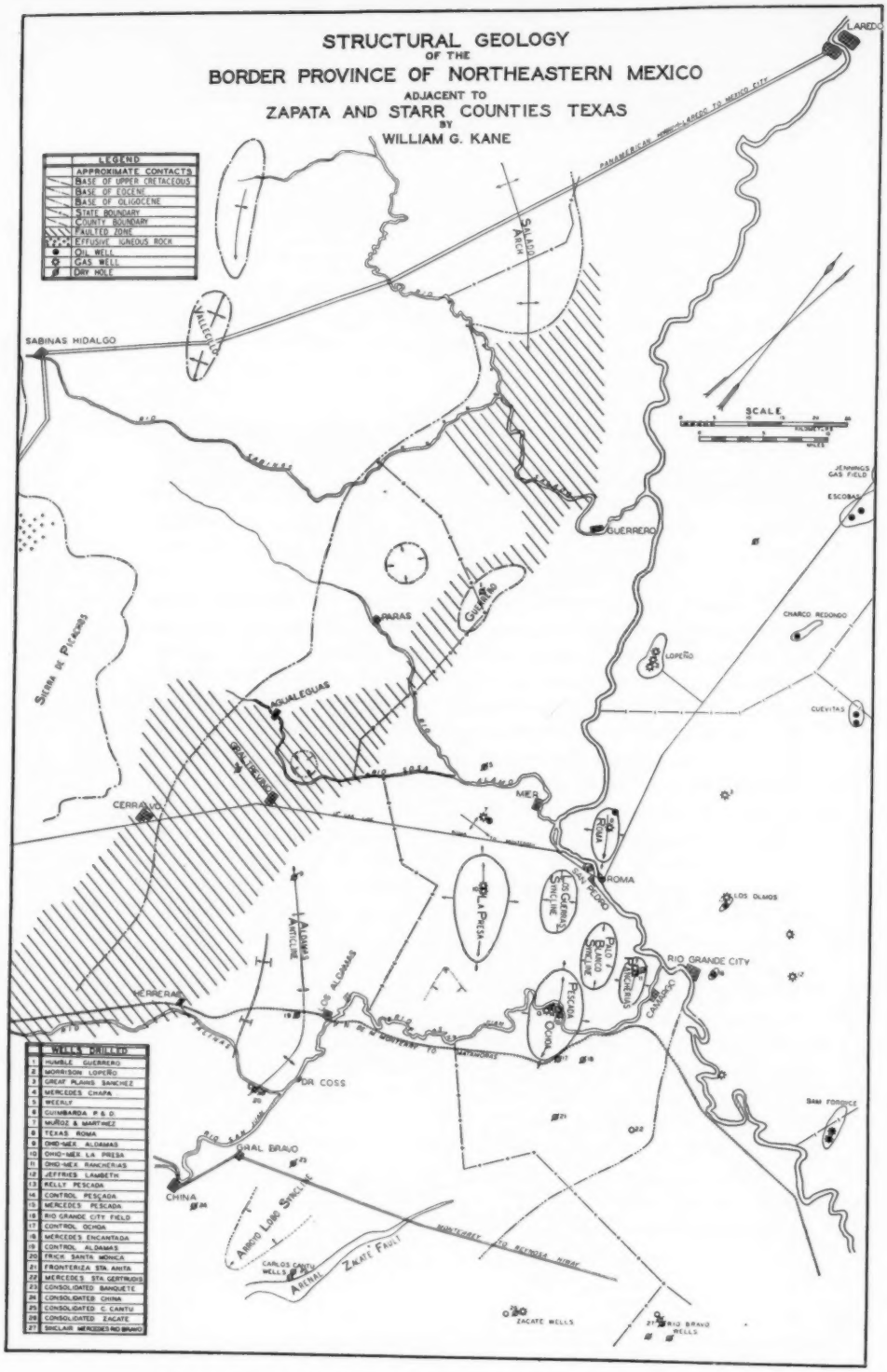


FIG. 1.—Structural geology of border province of northeastern Mexico.

this region is the paper by J. L. Tatum[3] on the general geology of northeast Mexico. This paper gives a comprehensive view of the general aspects of the structural geology of this province. While we are not in accord with the importance given the Tamaulipas arch in its projection into the structural problems of this area, we regard Tatum's concepts of the Sierra Madre and Front Range folding and faulting to be well founded and to serve as an excellent basis for the more complicated problems of the folding found in the Eocene beds. The Aldamas-Escalera terrace zone to which he first called attention is an important feature in the marginal area between the mountains and the plains. His careful study of the three physiographic provinces of the area and his descriptions of the Cretaceous beds with the structural implications of the local variations in stratigraphy are all very helpful contributions to an understanding of the structural geology of this region. It is thought, however, that a closer scrutiny of the position and relative size of the various known structures in this part of northeastern Mexico may lend some support to a modified concept of their origin and an enlarged significance to their location.

STRUCTURAL GEOLOGY

The structural geology of that part of the border province of northeastern Mexico adjacent to Zapata and Starr counties, Texas, is characterized by a type of folding not unlike that found on the east front of the Rocky Mountains in the United States. Most of the anticlines of this area have axes extending northwest and southeast and almost all of them plunge southeast. Most of the structures are of the same general pattern in that an easterly plunging nose begins almost abruptly from an otherwise regularly east-dipping homocline. This nose usually has little or no closure on the west. At an angle of approximately 120° from the axis of this nose is the anticlinal axis. The reversal is ordinarily well developed with the steeper dips on the east side. The closure of the structure is generally limited by the depth of the saddle between the northwest end of the anticline and the easterly plunging nose on the west. The manner in which the axes of these anticlines trend at oblique angles to the axes of the noses with which they are associated suggests that two sets of component forces might have been exerted against each other in forming the folds found in this province. Though it would be premature to attempt to postulate the projection into this area of some of the counteracting forces that were brought into play in the Monterrey sector of

[3] J. L. Tatum, "General Geology of Northeast Mexico," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, No. 8 (August, 1931), pp. 867–93.

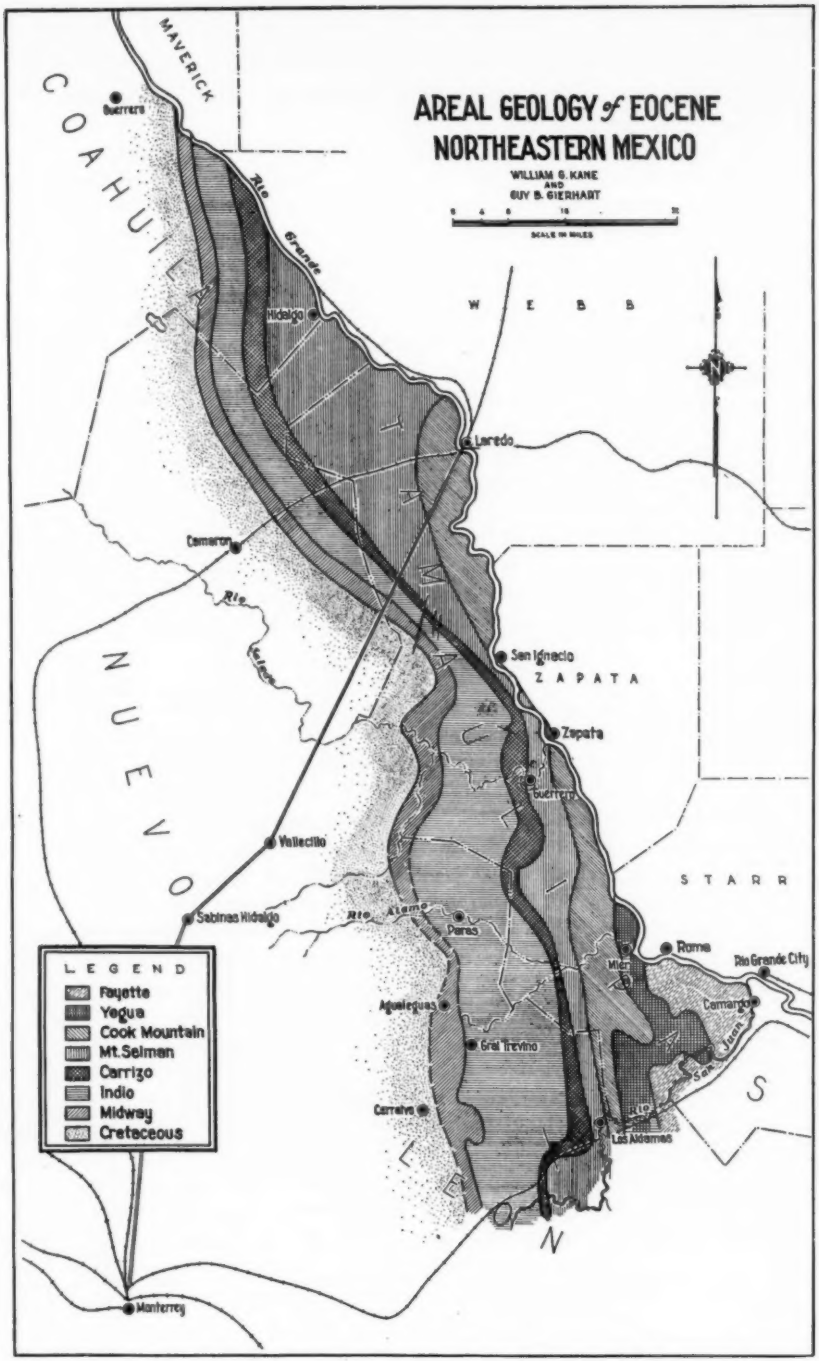


FIG. 2.—Areal geology of Eocene of northeastern Mexico. From Kane and Gierhart, "Areal Geology of Eocene in Northeastern Mexico," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 9 (September, 1935), pp. 1357–88. This article contains six detailed stratigraphic sections, four of which are road logs.

Sierra Madre folding, it is interesting to note that there is a certain degree of similarity between the different axes of folding here exhibited and those seen in the mountains west and south of Monterrey. The Sierra de Picachos with its southerly *en échelon* extension in the Sierra de Papagallos, the Salado arch, the Aldamas anticline, and the La Presa, Roma, and Rancherias folds, all exhibit the same characteristic of having the direction of their southeasterly or easterly plunging axes changed to south and southeast, respectively. In the Monterrey area the regular N. 20° W.–S. 20° E. trend of the axes of the Sierra Madre folding is disturbed by appearance of a series of east-west axes of folding extending eastward from the area at the south end of the Jurassic land mass in central Coahuila.[4] The effect of the intersection of these two great trends of folding is seen in the changing of the axis of such great mountain anticlines as the Sierra de Sta. Catarina from almost W.–E. to S. 30° E., which is only 10° from the normal trend of Sierra Madre folding seen in the Sierra de Sabinas and other mountain anticlines north of Monterrey. The distance from this Monterrey folding to the Rio Grande border province is not much greater than that to the San Carlos Mountains, and Kellum[5] has practically established a tectonic relationship between the latter areas. It is believed that when the paleogeographic problems of central Coahuila have been solved and the studies of Kellum, Imlay, Robinson, the writer, and others have been completed and coördinated, some interesting structural influences may be traced from that area eastward into the Eocene beds of the Gulf Coastal Plain.

From a study of the areal geological map of the Eocene in northeastern Mexico published in September, 1935,[6] it will be noted that little, if any, configuration is shown by the formation contacts north of the Laredo-to-Monterrey highway. On the other hand, southward from the southeast point of the Salado arch, near San Ignacio, the Eocene contacts exhibit irregularities which have important and sustained structural significance. Whereas at Escaleras, the zone of steep dips is on the northeast flank of the Salado arch, from San Ignacio southward the zone of steep dips is found along a line extending obliquely across the southeasterly plunging axes of such folds as the Salado arch, the Vallecillo anticline, and the Aldamas anticline. It

[4] Emil Böse, "Vestiges of an Ancient Continent in Northeast Mexico," *Amer. Jour. Sci.*, Vol. 6 (1923), pp. 127–36, 196–214, 310–37.

[5] L. B. Kellum, "Structure of the San Carlos Mountains, Mexico," *Bull. Geol. Soc. America* (abstract), Vol. 42, No. 1 (March, 1931).

[6] William G. Kane and Guy B. Gierhart, "Areal Geology of Eocene in Northeastern Mexico," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 9 (September, 1935), pp. 1357–88.

seems significant that most of the folding observed in the Eocene beds of northern Mexico is found in the sector east of this line of steeper dips extending from the point of the Salado arch southward along the east flank of the Aldamas anticline. It also appears significant that through this area all of the Eocene contacts are found trending in approximately the same direction in which they crossed the Rio Grande into Mexico, but that their outcrop has been moved eastward about 30 miles by the effects of the folding of the Salado arch, the Vallecillo anticline, the Sierra de Picachos, and the Papagallos Hills. This area of distorted Eocene beds along the Rio Grande is, moreover, directly adjacent to the old continental block in central Coahuila that had been affected by the two lines of east-west folding already mentioned.

The following is a brief description of the most important structural features of the area discussed in this article.

SIERRA DE PICACHOS (CERRALVO MOUNTAINS)

The Sierra de Picachos is a high anticlinal uplift that brings up the San Felipe and Tamasopa limestone, which are the equivalents of the Austin chalk, Eagle Ford, Georgetown, Edwards, and Glen Rose limestones in the Texas section. The axis of this fold changes from approximately N. 70° W.–S. 70° E. in the main Sierra de Picachos to S. 40° E. in the Sierra de Papagallos, its southerly *en échelon* extension. It is one of a group of more moderately folded anticlines forming the front ranges of the Sierra Madre Oriental. At its northern end it has been subjected to post-Cretaceous vulcanism. A rather large volcanic plug and remnants of a surrounding lava flow can be seen near the north end of this mountain south of the road from Sabinas Hidalgo to Monterrey, just before the road ascends the Cuesta de Mamalique. Neither this range nor the Sierra de Papagallos at the south exhibits the intense folding that characterizes the mountains farther west along the line of the main Sierra Madre movement. The peculiar erosion forms that characterize the outcrops of the steeply folded beds of the Sierra Madre proper are also absent here. At several places in the mountains west of Cerralvo, commercial lead deposits have been mined. The mineralization appears to be confined to replacement of some of the San Felipe and Georgetown limestones by lead carbonate ores. No igneous rock crops out at or near these mines.

CERRALVO FAULT ZONE

Flanking the Sierra de Picachos and the Papagallos Hills on the east is the Cerralvo fault zone, a structural geologic feature of major

importance. The beds affected by this fault zone are limited to the relatively incompetent shale and sandstone series east of the mountains. The wide zone of distortion included in this Cerralvo fault zone ranges from the Papagallos, or Taylor shale, across the Cretaceous-Tertiary contact into the Midway and Indio formations. The Cretaceous-Tertiary contact is near Cerralvo and from here eastward to the west flank of the Aldamas anticline, the structure is characterized by steeply dipping folds modified by intricate faulting. The zone of disturbance, as shown in the Tertiary beds in this locality, is almost 15 miles wide and it is probable that the same conditions extend westward into much of the area underlain with Cretaceous shale, between Cerralvo and the Sierra de Picachos. Laterally, or along the strike, this fault zone has been noted from the Ramones district in the south, northward through the Agualeguas district. Outcrops all along the Rio Sosa east of Gral. Trevino show this complex faulting as far east as the escarpments of the upper Indio formation near the Quirogas Ranch. Faulting and distortion of a similar nature are present west of the Guerrero dome and a series of block faults extend from here northward to the southeast point of the Salado arch near the Tanque Barreta and Tortillas areas. This fault zone does not extend north of the Laredo-to-Monterrey highway.

The extent of this fault system is such as to give it an importance comparable with that of the Balcones fault system in Texas. It is one of the most interesting and significant structural features in northeastern Mexico. It is shown on the accompanying map in cross-hatched lines.

So far, no fully acceptable explanation has been offered for this area of profound distortion. In the north end of the faulted zone at the southeast end of the Salado arch it is relatively simple to explain. Here a series of block faults is present on the northeast flank of the plunging nose of the arch. Each fault is downthrown toward the east. The direction of the step faults is almost at right angles to the axis of the arch. The faults disappear down-dip within 2 miles of the Cretaceous-Tertiary contact. Since another series of similar and compensating faults is found south of here between Tanque Barreta and Guerrero, this fault system is evidently due to simple adjustments incident to the rather sharp folding at the point of the Salado arch. The fault pattern becomes more and more complex from Guerrero southward to the Rio Sosa and the Gral. Trevino area, where the faulting and folding are so complex that they preclude detailed mapping in very large areas. The Cia. de Petroleo Mercedes drilled a well on a sharp anticline within this distorted zone. The hole was aban-

doned at 5,003 feet without having reached the Lower Cretaceous limestones. This zone of intense faulting and folding is still regarded by many as an area of considerable economic promise if a well could be drilled into the San Felipe and Tamasopa limestones that produce in the Tampico area. For the most part, faulting is confined to the areas where the Upper Cretaceous shales, and the Midway and Indio formations crop out. Faulting is relatively uncommon in the Claiborne and Jackson beds of the Eocene and such faulting as occurs in these upper beds is noted in connection with the respective structures.

SALADO ARCH

The Salado arch is a broad anticlinal feature in the north end of the Rio Grande border province. Its axis trends normally S. 50° E., but as it plunges south between Tortillas and Tanque Barreta this axis is changed to approximately S. 35° E. It is really an Upper Cretaceous and Lower Eocene expression of the southeast plunging axis of the Peyotes Hills anticlinal fold in the Austin and Eagle Ford beds. The Peyotes Hills anticline in turn is a southeasterly plunging nose off the southern end of the Burro Mountain anticline in the lowest Cretaceous beds. The axis of the Burro Mountain fold trends approximately S. 50° E.

The Salado arch extends along the southwesterly border of the outcrop of the Eocene beds in northeastern Mexico. Though angular unconformity is characteristic of the Cretaceous-Eocene contact in the north along the Rio Grande, this relationship appears to have been somewhat modified on the south, for Eocene beds swing around the southeasterly plunging axis of this arch.[7]

Several wells have been drilled on the Salado arch. Two were drilled by the Cia. de Petroleo Mercedes, on the Chancaca property. Both wells reached a depth of 3,500 feet and were abandoned as dry holes. A well was drilled about 3 miles east of Camaron by the Control de Administracion de Petroleo, Nacional, a Mexican Government agency. This well found the top of the Austin chalk at 3,380 feet and was abandoned in the Georgetown limestone at 5,323 feet. The well drilled by the Mexican Gulf Oil Company on the San Ambrosio property found the top of the Austin chalk at 3,114 feet and penetrated the full section of Lower Cretaceous limestones. This well encountered hot salt water at 9,312 feet and was abandoned.

[7] Richard A. Jones, "A Reconnaissance Study of the Salado Arch, Nuevo Leon and Tamaulipas, Mexico," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 9, No. 1 (February, 1925), pp. 123–33.

GUERRERO DOME

The Guerrero dome is a well developed anticline with a zone of intense faulting and fracturing along its west flank. The beds at the surface are Carrizo sandstone. A well drilled by the Cia. Petrolera Tamaulipas, S.A., a subsidiary of the Humble Oil and Refining Company, was abandoned at 7,891 feet without having reached its objective—the San Felipe limestone.

VALLECILLO ANTICLINE

The Vallecillo anticline is a symmetrical fold in the Eagle Ford or San Felipe beds. It is crossed by the highway from Laredo to Monterrey about 68 miles southwest of Laredo. Its axis extends approximately N. 20° W., parallel with the main Sierra Madre trend of folding. The dips on all sides of this anticline are moderately low and typical of the front-range type of folding. As in the case of the Sierra de Picachos west of Cerralvo, some of the San Felipe beds were mineralized by replacement of limestone by lead carbonates. No igneous rocks are known to crop out on the Vallecillo anticline, but the Sierra de Iguana northwest of it has been subjected to post-Cretaceous vulcanism.

ALDAMAS ANTICLINE

The Aldamas anticline is a long southeasterly plunging fold east of the front range of mountains, the Sierra de Picachos. Its axis trends S. 50° E. as far south as the Monterrey-to-Matamoras railroad, but farther south its direction is changed to almost due south. The axis of this great structural feature has been traced for a distance of 30 miles below the point where it crosses the Rio Sosa, but its location in the area north of the river is obscured by widespread caliche and gravel covering the Eocene beds. The eastern limit of the Cerralvo fault zone is found along the western flank and across the north end of this anticline.

Several years of detailed study were given to this structure by the writer. On its east flank are found high escarpments of Carrizo and Indio sandstones. These swing around the south end of the structure with a great S turn. The so-called "Once Lomas," just west of Aldamas and north of the railroad, gives a classic exhibition of a plunging anticlinal nose with a plunging syncline west of it. Faulting is very conspicuous throughout this part of the area.

At a point approximately 12 miles northwest of where the axis of this structure crosses the railroad west of Aldamas Station, a well

was located on a high point of the anticline just east of the margin of the complicated Cerralvo fault zone. This well was drilled by the Ohio-Mexico Oil Corporation in 1929 with the San Felipe limestone as its objective. The well samples were black shale from the surface to the bottom at 4,380 feet. The paleontologists were in wide disagreement about the depth at which this well went out of the Midway into the Cretaceous and none of them was very optimistic about the chances of reaching the San Felipe limestone at a reasonable depth. In the meantime the Humble well at Guerrero had been drilled to a depth of 7,891 feet without reaching the San Felipe limestone and the Mercedes Chapa well had gone to a depth of 5,003 feet without reaching it. Since the La Palma well started only about 2,000 feet lower stratigraphically than the Humble well, it was indicated that to reach the point in the section at which this Guerrero well was abandoned, a 6,000-foot hole at La Palma would be necessary. It is unfortunate that none of these three wells reached the San Felipe limestone, for a wide area characterized by structural conditions of the greatest promise, with respect to limestone production, is thus consigned to the realm of deep drilling. Almost all of the major companies have lost interest in this area, for the time being at least, although all agree that none of the wells drilled was a complete test of its possibilities.

The south Aldamas structure is on the nose plunging southward off the Aldamas anticline south of the railroad where the axis of the fold has been deflected westward. An oblique fault cuts across its crest, trending toward the Frick wells on the Rio Salinas. These wells had some oil and gas showings, but all were abandoned without having encountered anything of commercial importance.

The east flank of the Aldamas fold presents a series of parallel outcrops of more than 4,000 feet of east-dipping beds ranging from the Indio formation to the upper Cook Mountain formation before the first traces of the nose that develops into the La Presa anticline are seen.

LA PRESA ANTICLINE

The axis of La Presa anticline is approximately N. 42° W. Like many other structures in this region, it is a west-east nose coming off the normal regional east-dipping beds on the west. The saddle in which closure is formed is the point at which the trend of the axis of this plunging fold turns from easterly to southeasterly. The syncline immediately west of the location of the two La Presa gas wells indicates a reversal of more than 800 feet, while the closure on this structure, as revealed by very detailed plane-table mapping, is a

little more than 350 feet. The Cook Mountain-Yegua contact makes a broad S turn around the south end of the structure and the *Turritella* bed seen on the Mier to Gral. Trevino road can be traced all the way around the structure. This unusually dependable datum plane, as well as other good resistant beds, offered ample opportunity for accurate structural mapping.

The surface beds at the La Presa gas wells are about 490 feet below the top of the Cook Mountain formation. It is the consensus of opinion of paleontologists who have made a microscopic examination of the cuttings of this well that the top of the Weches formation was encountered at 1,030 feet and that the top of the Queen City formation was found at 1,300 feet. From these determinations, it seems that the first gas sand, at 1,280 feet, was near the bottom of the Weches formation and the second gas sand, at 1,480 feet, was in the Queen City formation. Several faults are found cutting across the La Presa structure east and west. Except for one long fault which can be traced for more than 5 miles beyond the structure, all of them are confined within the area of the anticline itself.

The initial production of the two wells was estimated by the United Gas Company as 19 million cubic feet per day. These wells are now connected to the pipe line of the Compania Mexicana de Gas, which serves the city of Monterrey. They represent the first commercial production in northern Mexico. The potentialities of this structure are still very great, when it is considered that the deepest well to date has penetrated only 2,000 feet of beds. Within reach of the drill are several thousand feet of promising beds, including the lower Mount Selman, the Carrizo, and the Indio formations. This structure was first seen in an airplane reconnaissance of the region in 1928 and the discovery well was completed by the Ohio-Mexico Oil Corporation in October, 1931.

The east-west trending nose, a few miles northwest of the La Presa structure, has had two wells drilled on it by Munoz y Martinez. Their well No. 1 produced 20 million cubic feet of gas daily when it was first turned into the gas line, but its diminishing output since that time has been disappointing. Their well No. 2 had an excellent showing of oil. Pipe was set nearly a year ago, but it has never been drilled in. The oil and gas in this area is from approximately the same horizon as the La Presa gas sands.

OCHOA-PESCADA ANTICLINE

The Ochoa Pescada structure is a large and well developed closed anticline with an axis trending approximately N. 30° W. The crest

of this fold crosses the Rio San Juan about 3 miles east and 3 miles north of the town of Ochoa. It shares with the La Presa anticline the distinction of being one of the two best closed anticlines of the Eocene-Tertiary in northeastern Mexico. Though there is not available a complete contour map of this structure, it seems reasonable, based on plane-table work in the area, that it should have 250 feet or more of closure. The beds of the Yegua formation are at the surface, and the top of the Weches formation was found at a depth of 2,800 feet. No faults have been mapped on this structure.

Several wells have been drilled on this structure: one by the Control de Administracion del Petroleo Nacional, to 3,601 feet; a second by Kelley *et al.*, to 4,107 feet; and a third by the Cia. de Petroleo Mercedes, to 5,750 feet. All three wells found some gas and two of them reported considerable oil showings. However, none of them was completed as a commercial producer. There are several deeper horizons on this structure that offer good possibilities and are as yet untested.

ZACATE FAULT

Although the writer has but little detailed information regarding the Zacate fault, it is obviously one of the most important structural features in the Eocene area south of the Rio San Juan. Tatum considered it to have a displacement of 1,000 feet with the downthrow on the east. The Arenal formation which he maps along the outcrop of this fault is of itself an interesting problem in stratigraphy and speculative physiography. What with the reported unconformities at the base of the Jackson and even within the Jackson itself, variable stratigraphic conditions in the lower beds, and other complications that come into the stratigraphy and structural geology of the Eocene below the Rio San Juan, many of the structural relations in this part of the area may long remain matters of conjecture.

ROMA ANTICLINE

The Roma anticline is a small anticline with probably not more than 50 feet of closure, plunging S. 42° E. from an east-west nose crossing the Rio Grande north of Mier. A rather thorough test of several of the most desirable locations on this structure has been somewhat disappointing, although several gas wells and one small oil well have been completed in the Queen City formation. This is approximately the same horizon from which gas is being produced from wells on the Lopeno, La Presa, and the Munoz y Martinez structures. The beds exposed on the top of the structure are thought to be only a few hundred feet above the base of the Fayette formation. Although

one well was drilled to a depth of 4,827 feet, it is not believed that beds older than Mount Selman were penetrated. The top of the Weches formation was encountered at depths ranging from 3,217 to 3,395 feet. The southeasterly plunging axis of this structure crosses the Rio Grande into Mexico at a point about ½ mile above Roma. The Roma structure is owned and has been developed by The Texas Company.

RANCHERIAS STRUCTURE

The Rancherias structure is a relatively small closed anticline lying several miles southwest of the confluence of the Rio San Juan and Rio Grande. It has more than 600 feet of reversal but perhaps not more than 100 feet of closure. There is, however, cross faulting of considerable magnitude which may give added closure on the north.

Like the La Presa anticline, the Rancherias structure was first seen in 1928 on airplane reconnaissance, but the discovery well was not completed by the Ohio-Mexico Oil Corporation until 1933. The beds at the surface are middle Jackson in age. The *Textularia diboll-lensis* zone was encountered at 600 feet, the *Nonionella cockfieldensis* at 890 feet, and *Eponides yeguaensis* at 1,030 feet. Gas in commercial quantities was found in almost every sand from 90 feet to the total depth of 1,271 feet. At this depth the total production exceeded 60 million cubic feet per day. The second well was drilled on the east flank of the structure. It encountered gas in some of the shallow sands, but salt water was found in some of the main gas sands of well No. 1. Good oil showings, however, indicated good oil prospects a little higher on the structure. The third well drilled near the top of the structure encountered the same quantities of gas that characterized well No. 1, and at 1,939 feet a 7-foot oil sand was cored. Gas of tremendous volume and pressure between the top of the oil and the bottom of the pipe precluded a successful completion as an oil well, but it will make a large gas well.

The excellent results obtained in wells No. 1 and No. 3 on this structure seem to offer great promise for production not only from the lower Jackson, but from the Yegua formation as well, if these sands can be found on closed structures in adjacent areas in Starr County, Texas.

SYNCLINES

One of the exceptional things about the structural geology of this area is the presence of at least five perfectly closed synclines. While it is natural to have synclines between the anticlinal folds, it is not everywhere that an area is found in which closed synclines are so

prevalent. The closed syncline about 6 miles north of Paras, Nuevo Leon, Mexico, is perhaps the most nearly perfect the writer has seen. It is almost round and the concentric rings formed by the outcrops of its encircling escarpments show remarkably well from an airplane. A smaller, but none the less perfect, closed anticline is found on the north bank of the Rio Sosa just north of the town of Gral. Trevino. Another, not quite so apparent at first sight, is the closed syncline in the lower Jackson beds between the Roma, La Presa, and Ochoa-Pescada structures. One of the largest and most nearly perfect closed synclines is the Palo Blanco syncline, which lies between the Roma, Rancherias, and Ochoa-Pescada structures. The beds in the center of the structure are upper Jackson in age and its encircling escarpments bring up beds that are nearly 1,000 feet lower on the structure adjacent to it. A fine opportunity is thus afforded to make almost exact stratigraphic correlations of these structures with one another. While the opportunity has not been afforded the writer to make a detailed study of the Arroyo Lobo syncline west of the great Zacate fault, it is felt that this structural trough must be one of the largest in the entire area. The structural relations at the north end of this great synclinal area are still obscure to the writer.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGIST
VOL. 20, NO. 4 (APRIL, 1936), PP. 417-432, 3 FIGS.

PALEOGEOGRAPHY OF PARTS OF BORDER PROVINCE OF MEXICO ADJACENT TO WEST TEXAS[1]

LEWIS B. KELLUM[2]
Ann Arbor, Michigan

ABSTRACT

A present trend in petroleum exploration is the search for buried shore lines. During Jurassic and Neocomian time the southern margin of the North American continent extended across northern Mexico and formed a peninsula extending southward across Coahuila. The basement rocks of this peninsula are to-day exposed in the deep canyons and along the pediments of some of the mountain ranges of Coahuila. The Mexican geosyncline lay adjacent to this peninsula on the east, west, and south. Much of the clastic sediment which accumulated in the geosyncline in Coahuila, and in eastern Chihuahua and Durango, was derived from this land mass.

In Aptian time the peninsula was peneplaned and the sea transgressed across it. Lagoons formed on the slowly subsiding land and gypsum deposits of great thickness and lateral extent accumulated in them. A gypsiferous facies in the Aptian-Albian series of Coahuila is closely limited to the area previously occupied by the peninsula.

The distribution of Upper Jurassic and Lower Cretaceous marine sediments, as well as certain similarities in the fossil faunas of these sediments in the Mexican geosyncline and in the Pacific geosyncline, strongly suggest a connection between the Atlantic and Pacific across northern Mexico during certain stages of the Mesozoic.

The Coahuila peninsula controlled the type of structures which developed during the Tertiary in the overlying sediments. There is a marked contrast between the relatively simple, open folding of Lower Cretaceous rocks above the peninsula, and the tight, asymmetrical folding and overthrusting in the area of the geosyncline on the east, west, and south. This relationship is similar to that observed elsewhere associated with foreland blocks.

ACKNOWLEDGMENTS

The studies of the writer and his associates, on which the present paper is primarily based, have been made under the auspices of the University of Michigan. They were supported by the Geological Society of America, the National Research Council, and the University of Michigan. In the preparation of the paper, the writer has drawn freely upon the unpublished reports of his associates and upon many published sources. Credit has been given in the footnotes or in the text for statements and ideas taken from other writings. The writer wishes to express special appreciation for the coöperation and assistance of his friends and colleagues: R. W. Imlay, W. A. Kelly, and W. G. Kane. He is especially indebted to the Geological Society of America for permission to present this paper before the American

[1] Read before the Association at the mid-year meeting, in Mexico City, October 17, 1935. Manuscript received, January 30, 1936. Published by permission of the Geological Society of America.

[2] Curator of Mesozoic and Cenozoic Invertebrates, Museum of Paleontology, University of Michigan.

Association of Petroleum Geologists and to publish it in the *Bulletin* of the Association.

INTRODUCTION

Paleogeographic studies have assumed increasing importance in petroleum exploration as the more easily recognized oil traps were

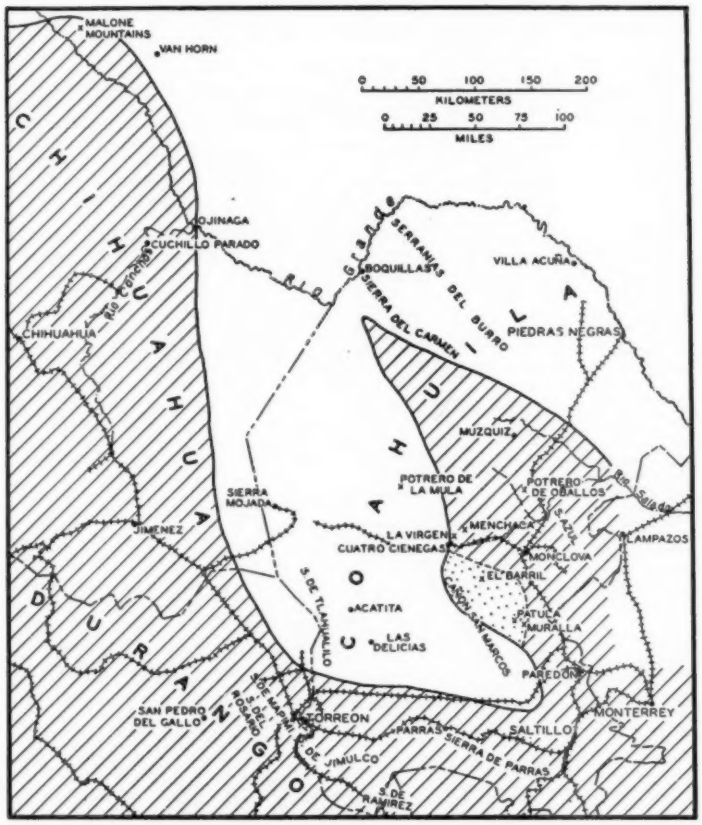


FIG. 1.—Neocomian paleogeography of Coahuila and parts of adjoining states. Unshaded area in western Coahuila, eastern Durango, and Chihuahua is the massif of the Coahuila peninsula (foreland block). Dotted area on the east side of the peninsula is a region where arkose is abundant in the Neocomian sections. Lined areas represent Neocomian seas where the deposits contain little or no arkose. Along the east and northeast edge of the map the absence of shading indicates a lack of definite information regarding the Neocomian section.

Upper Jurassic paleogeography of this area was almost identical with that of the Neocomian except that the Coahuila peninsula was somewhat larger and extended south of Torreón.

tested and new ones have become difficult to find. A present trend is the search for buried shore lines. Shore sands are suitable reservoir beds, commonly sealed at unconformities and connected seaward with highly organic source beds. During Jurassic and Neocomian time the southern margin of the North American continent extended across northern Mexico from southern Coahuila into California. The sea transgressed slowly northward. Its progress was modified by warpings of the earth's crust, by outpourings of lava, and by uplift of the lands. In southern Coahuila a part of this old shore line has been disinterred by erosion of the overlying cover. We can examine it on the surface over a broad area and see its relation to the structure of enclosing rocks. The projection of this shore line to the northeast beneath the cover of overlying strata may well lead to a reservoir in areas where source beds of petroleum interfinger with or overlie this shore facies.

The Jurassic-Neocomian shore line formed a peninsula which extended southward and covered most of the state of Coahuila. Exposures of this foreland can be seen in the deep canyons and along the pediments of the rugged mountain ranges of Coahuila. There is a pronounced angular unconformity between the basement rocks of the old peninsula and the overlying Cretaceous. Such an unconformity does not exist in near-by areas on the east, west, and south. Thousands of feet of marine Neocomian and Jurassic strata have accumulated beneath the Aptian in southern and eastern Coahuila, eastern Durango, and eastern Chihuahua. Equivalent strata are completely absent in western Coahuila where the foreland stood. Overlap relationships of Jurassic and Neocomian sediments from south to north can be seen on the margins of the land mass. A gypsiferous facies in the Aptian-Albian series in western and central Coahuila is closely limited to the area previously occupied by the peninsula. Finally, there is a striking contrast between the relatively simple folding of the Lower Cretaceous limestone in areas where the surface of the foreland is exposed, and the belt of complex folding in the geosynclinal area contiguous to it. These observations show the convergence of varied lines of evidence demonstrating the former existence of the land mass in Coahuila and that it was an important factor in modifying the sedimentation and diastrophism of subsequent geologic periods.

COAHUILA PENINSULA AND ADJACENT PORTIONS OF MEXICAN GEOSYNCLINE

The basement rocks of the Coahuila peninsula crop out in southern Coahuila (1) along the western side of Las Delicias valley, (2) along the eastern side of Acatita valley, and (3) in canyons at the central

TABLE I

Correlation Chart of Recently Described Sections in Northern Mexico

EUROPE				ACATITA–LAS DELICIAS REGION (after W.A. Kelly)	MTNS. WEST OF LAGUNA DISTRICT (after L.B. Kellum)	SIERRA DE LA PEÑA (after T.E. Jones)	SIERRA DE PARRAS WESTERN PART (after R.W. Imlay)	MIDDLE PART OF SIERRA DE PARRAS (after R.W. Imlay)	SAN CARLOS MOUNTAINS (after L.B. Kellum)	NORTHERN OIL FIELDS (modified after J. Muir)		TEXAS (after W.S. Adkins)	CALIFORNIA (after P.M. Anderson)	
UPPER CRETACEOUS	SENONIAN	MAESTRICHTIAN		HIATUS	HIATUS	HIATUS				HIATUS		NAVARRO GROUP 450' TO 2830'		
		CAMPANIAN					DIFUNTA FORMATION 12000'+	DIFUNTA FORMATION	MENDEZ SHALE 2952	MENDEZ SHALE 800'–1000'		TAYLOR GROUP 375'–1400'		
		SANTONIAN					PARRAS SHALES 2500+	PARRAS SHALES 4000'(ESTIMATE)						
		CONIACIAN					INDIURA FORMATION 8120'	CARACOL FORMATION 850'		SAN FELIPE FORMATION	SOLIS LIMESTONE MEMBER 300'–500'	AUSTIN GROUP 225'–1000'	?	
		TURONIAN		INDIURA FORMATION 100'	INDIURA FORMATION 100'–1000' (ESTIMATE)	INDIURA FORMATION 1300'±		INDIURA FORMATION 900'	SAN FELIPE FORMATION 1000'(ESTIMATE)		AGUANUEVA MEMBER 250'–400'	EAGLE FORD GROUP 80'–225'		CHICO FORMATION 7000'–21000'
		CENOMANIAN	UPPER									WOODBINE GROUP 5'–625'		
			MIDDLE									WASHITA GROUP 180'–800'		
			LOWER											
LOWER CRETACEOUS	NEOCOMIAN	GAULT VRACONIAN	UPPER				CUESTA DEL CURA LIMESTONE 210'–230'	CUESTA DEL CURA LIMESTONE 680'				FREDERICKSBURG GROUP 500'		
		ALBIAN	MIDDLE	AURORA LIMESTONE 1000'	AURORA LIMESTONE 2000'±(ESTIMATE)	AURORA LIMESTONE 435'+	AURORA LIMESTONE 420'–740'	AURORA LIMESTONE 600'–2330'				GLEN ROSE FORMATION 90–1066		
			HORIZON OF CLAM BEDS	CUCHILLO FORMATION 1700'								CUCHILLO FORMATION 600'		
			GARGASIAN		LA PEÑA FORMATION 240'–325'	UNEXPOSED	LA PEÑA FORMATION 1420'–2250'	LA PEÑA FORMATION 1200'						
		APTIAN	BEDOULIAN	HIATUS	LAS VIGAS FORMATION 2125'–3450'		PARRITAS FORMATION 1120'	CUPIDO LIMESTONE 1136'	TAMAULIPAS LIMESTONE	TAMAULIPAS LIMESTONE 1685'–1700'		LAS VIGAS FORMATION 730'		HORSETOWN BEDS 1660'
		BARREMIAN	UPPER				LAS VIGAS FORMATION 645'							
			LOWER											
		HAUTERIVIAN												
		VALANGINIAN			TORCER FORMATION 2395'		TARAISES FORMATION 470'–487'	TARAISES FORMATION 300'–235'				TORCER FORMATION 63'		PASHENTA BEDS 4850'
		BERRIASIAN					HIATUS	HIATUS						
UPPER JURASSIC		PORTLANDIAN	TITHONIAN OR AQUILONIAN										KNOXVILLE SERIES 14250'–16000'	
			LOWER											
		KIMMERIDGIAN					LA CASITA FORMATION 200'	LA CASITA FORMATION 185'–250'		HIATUS				
		OXFORDIAN	UPPER											
			LOWER				LA GLORIA FORMATION 1000'	LA GLORIA FORMATION 2170'						

part of Sierra de Tlahualilo. In central Coahuila they crop out in the Potrero de la Mula, northwest of the village of Ocampo. In northern Coahuila they are exposed in the Sierra del Carmen. A review of the lithology of the basement complex in each of these areas, shows that the pre-Aptian foreland of western Coahuila was formed (1) in the south, by marine Permian sedimentary rocks and lavas, by Permian or post-Permian intrusive granites and granodiorites, and by a series of phyllites, quartzites, slates, shales, and conglomerates of Paleozoic age, probably in part Permian; (2) in central Coahuila by granitic rocks and associated dikes and quartz veins; and (3) in the north, by pre-Cambrian mica schist. The basement rocks probably crop out at other localities in northern and western Coahuila, but many of the high mountain ranges, accessible only with difficulty, have not yet been studied.

Examination of the pre-Aptian stratigraphic sections so far described around the margins of the Coahuila peninsula, indicates a fluctuating shore line throughout Upper Jurassic and early Cretaceous time, with a dominant advance of the sea by encroachment on the land. Neritic facies are characteristically developed close to the ancient land and more bathal facies in areas at some distance from it. Thick wedges of clastic sediments begin at the continental margin and become rapidly thinner offshore; limestone wedges appear in the section and become thicker seaward from this ancient shore line.

On the eastern side of the Coahuila peninsula, in the region southeast of Cuatro Cienegas and southwest of Monoclova near the eastern line of the state of Coahuila, the stratigraphic sections which have been studied contain thick formations of coarse conglomerate, agglomerate, and arkose (Fig. 1). The probable source of much of this debris has been traced with some assurance to outcrops of the basement complex which composed the ancient land mass. A suite of rocks from very coarse conglomerates in the San Marcos valley is almost identical with a suite collected from the igneous, metamorphic, and sedimentary rocks of Paleozoic (?) age which crop out in places along the eastern side of the Acatita valley in southwestern Coahuila. These coarse clastics must have been deposited close to the margin of the continent, for agglomerates in them locally contain angular and subangular blocks several feet in diameter. As pointed out by Burckhardt,[3] the thickness of these deposits diminishes notably from south to north. This implies that the source of the debris lay at the south and is one line of evidence for an eastward extension of the pre-Aptian

[3] Carlos Burckhardt, "Étude synthétique sur le Mésozoïque mexicain," *Mémoires de la Société Paléontologique Suisse*, Vol. 49 (1930), p. 145.

land mass in southern Coahuila to the present site of Sierra de Alamitos and Sierra de la Paila. The distribution of the thick sections of arkose, et cetera, northeast of these so-called brachy-anticlines and southeast of the Neocomian shore line projected through Cuatro Cienégas, suggests that this coarse debris accumulated in a gulf or reëntrant on the eastern side of the land mass. It further indicates that much of the adjacent land was composed of granite and related rocks.

INTEROCEANIC STRAITS

Similarities have been recognized between the Mesozoic formations of California and those of the Mexican geosyncline. The boreal genus *Aucella* occurs in Upper Jurassic sediments at Catorce, San Luis Potosí,[4] and at San Pedro del Gallo, Durango,[5] in north-central Mexico. It occurs abundantly in California in the Knoxville series,[6] ranging from Middle Portlandian to Upper Aquilonian.

The ammonite genus *Protothurmannia*, belonging to the *Berriacellidae*, occurs in the Franciscan series at Nipomo, San Luis Obispo County, California.[7] This is distinctly a mediterranean element and belongs to a fauna which is widespread in the Tithonian (Upper Jurassic) of northern Mexico.

Ammonites identical with, or very closely related to, *Hoplites hyatti* Stanton and *Hoplites angulatus* Stanton occur in Portlandian shales of Sierra de Jimulco in the southwestern corner of Coahuila. These species have long been known in the Knoxville series in California.

Upper Jurassic crinoids from the Altar district, in northern Sonora, are positive evidence of a marine invasion of Sonora in Jurassic time.[8]

From stratigraphic studies in northern Mexico and the faunal relationships with the Upper Jurassic of the Pacific coast, Burckhardt concluded that in Upper Jurassic time a narrow arm of the sea connected the two oceans and separated two continents. He says[9]

> . . . the faunistic relations of the Kimmeridgian and Portlandian with central

[4] Antonio del Castillo and José G. Aquilera, "Fauna Fosil de la Sierra de Catorce, San Luis Potosí, *Comisión Geológica de México Boletín 1* (1895), p. 4.

[5] Carlos Burckhardt, "Faunes Jurassiques et Cretaciques de San Pedro del Gallo, *Instituto Geológico de México Boletín 29* (1912), p. 222.

[6] F. M. Anderson, "Knoxville-Shasta Succession in California," *Bull. Geol. Soc. Amer.*, Vol. 44 (1933), p. 1253.

[7] C. H. Crickmay, "A New Jurassic Ammonite from the Coast Ranges of California," *Amer. Midland Naturalist*, Vol. 13, No. 1 (January, 1932).

[8] Carlos Burckhardt, "Étude synthétique sur le Mésozoïque mexicain," *Mémoires de la Société Paléontologique Suisse*, Vol. 49 (1930), p. 82.

[9] Carlos Burckhardt, *ibid.*, pp. 103–04 (translation).

Europe and the Mediterranean region on the one hand and with the Russo-boreal region on the other demand a communication between the Tethys and the sea of western America.

The Neocomian faunas of the Pacific coast, as well as those from central Mexico, have until recently received only sporadic study and relatively few of the fossils already collected have been described and figured. The most recent publication on the Neocomian stratigraphy of the Pacific coast is a noteworthy paper by F. M. Anderson.[10] He does not recognize a marine connection between California and eastern Mexico during this period, but he records in California such ammonite genera as *Bochianites*, *Neocomites*, *Simbirskites*, *Lytoceras*, *Astieria*, *Steueroceras*, and *Polyptychites*, which are well known in the Neocomian of central Mexico. One species which he refers to *Astieria* cf. *astieri* d'Orbigny, is characteristic of the mid-Valanginian. Böse has described a species of this affinity from the Valanginian of Sierra de Symon on the Durango-Zacatecas state line and several other species belonging to the genus *Astieria* at the same horizon elsewhere in northern Mexico. Imlay found the *Astieria* beds well developed in the Sierra de Parras of southern Coahuila.

In the Cabullona basin of northeastern Sonora,[11] Lower Cretaceous sediments have a thickness of more than 8,000 feet. At the base is the Glance conglomerate deposited on land and in the encroaching Lower Cretaceous sea. Above it is the Morita formation of sandstones, grits, and shales, which in this area have not yielded any fossils. At the top of the section, and resting conformably on the Morita, is the Mural limestone. It has a thickness of about 700 feet and contains a molluscan fauna.[12] In the Bisbee district of Arizona, about 30 miles farther north, the fauna of the Mural limestone has been determined to be largely of Glen Rose age and possibly in part Fredericksburg.[13] The Morita formation is to be correlated at least in part with the Las Vigas and Torcer formations of western Texas and northern Mexico.

Farther south in northern Sonora fossiliferous marine Neocomian sediments have been recognized at several localities near the town of Santa Ana and at La Sultana mine, northeast of Horcasitas.[14]

[10] F. M. Anderson, *op. cit.*, p. 1264.

[11] N. L. Taliaferro, "An Occurrence of Upper Cretaceous Sediments in Northern Sonora, Mexico," *Jour. Geol.*, Vol. 41, No. 1 (1933), pp. 12–37.

[12] E. T. Dumble, "Notes on the Geology of Sonora, Mexico," *Trans. Amer. Inst. Min. Eng.*, Vol. 29 (1900), pp. 135–37.
Carlos Burckhardt, "Étude synthétique sur le Mésozoïque mexicain," *Mémoires de la Société Paléontologique Suisse*, Vol. 49 (1930), pp. 177–78.

[13] F. L. Ransome, "The Geology and Ore Deposits of the Bisbee Quadrangle, Arizona," *U. S. Geol. Survey Prof. Paper 21* (1904), p. 70.

[14] Carlos Burckhardt, *op. cit.*, p. 150.

These occurrences of the Neocomian and Comanche sediments in northern Sonora extend the known distribution of the early Cretaceous seas close to the Pacific. There seems to be a good probability

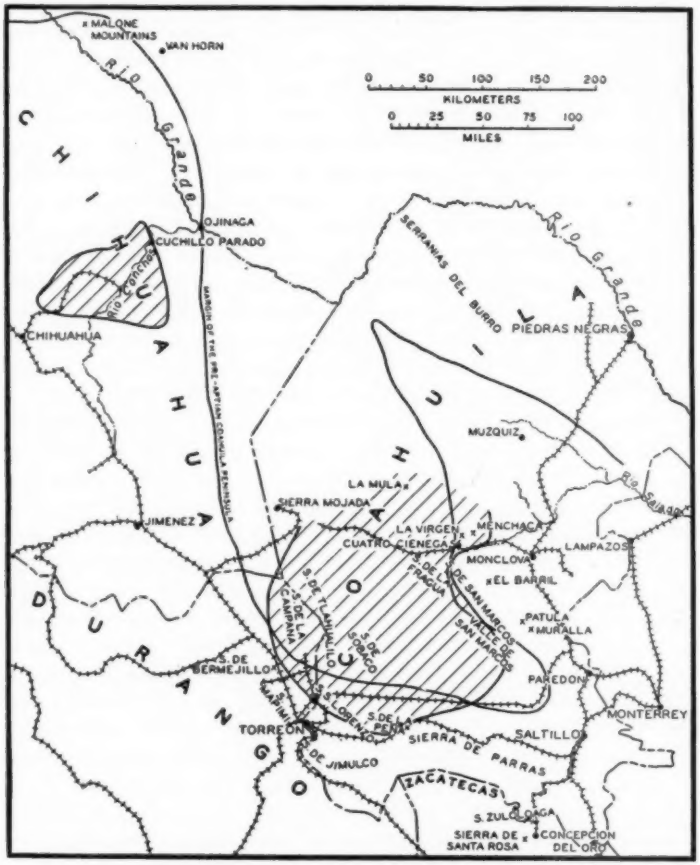


FIG. 2.—Map showing known distribution of lagoonal facies (shaded areas) in Aptian-Albian series and margin of pre-Aptian Coahuila peninsula.

that the Pacific and the Atlantic were connected across northern Mexico during certain stages of Neocomian time. The publication of faunas already known in California and in Mexico should demonstrate the presence or absence of an open seaway during the early Cretaceous.

LAGOONAL FACIES OF APTIAN-ALBIAN DEPOSITS IN COAHUILA AND CHIHUAHUA

GENERAL STATEMENT

Throughout a large area in southern and central Coahuila, the Aptian-Albian deposition is characterized by a gypsum facies (Fig. 2). Beds of this material, according to Kelly,[15] vary from a few inches to 10 feet in thickness and alternate with limestone, dolomite, chert nodules and lenses, and subordinate clastic material. The gypsum is usually more conspicuous, though less in quantity, than the other sediments. This facies is included in the Cuchillo formation, which in the mountains bordering the valleys of Acatita and Las Delicias has a thickness of about 1,500 feet.[16]

The distribution of this facies has now been closely delimited on the east, west, and south. Observations in the north, that is, in central and northern Coahuila, are as yet too meager to permit definition of the northern extent of the post-Neocomian Lower Cretaceous gypsum deposition. On the east the Cuchillo formation extends as far as the San Marcos valley in eastern Coahuila; on the west it terminates between Sierra de Campana and the Sierra de Bermejillo in eastern Durango; on the south it dies out between Sierra de San Lorenzo and Sierra de Jimulco in southernmost Coahuila.

LAGOONAL FACIES OF NORTHEASTERN CHIHUAHUA

In the Lower Cretaceous of northeastern Chihuahua, Burrows[17] has described the Cuchillo formation. The lower 1,500 feet is almost pure gypsum and the upper 500 feet consists of alternate beds of gypsum and limestone, passing into pure limestone at the top. Burckhardt and Böse have determined the age of this formation as Upper Aptian. In the Sierra de Sobaco, Kelly[18] has found Upper Aptian fossils in the basal limestone below a thick section of gypsum-bearing beds, and has retained the name "Cuchillo formation" for this series. Whether the gypsum-bearing beds of northeastern Chihuahua are connected with those of southern and central Coahuila or whether they represent a distinct lagoon separated by a narrow belt of continuous limestone deposition has not yet been determined. However, they have similar lithologic features and have about the same position

[15] W. A. Kelly, "Geology of the Mountains Bordering the Valleys of Acatita and Las Delicias," *Bull. Geol. Soc. Amer.* (in press).

[16] W. A. Kelly, *ibid.*

[17] R. H. Burrows, "Geology of Northern Mexico," *Boletín de la Sociedad Geológica Mexicana*, Tomo VII, Primera Parte (1910), p. 95.

[18] W. A. Kelly, *op. cit.*

in the stratigraphic section in the two regions. It is the writer's opinion that the name "Cuchillo formation" should be used for the gypsiferous facies of the Aptian-Albian series, since Burrows first used it in that sense, and the top and bottom limits have not been determined on paleontological evidence.

SIGNIFICANCE OF GYPSUM FACIES IN APTIAN-ALBIAN SERIES

The most striking fact in the distribution of this gypsum is that it closely follows the area where the southern peninsula of the pre-Aptian massif formerly existed. Böse[19] implied some relationship between the two when he postulated that gypsum interbedded with marl and limestone in the "Middle Cretaceous" of Sierra de San Lorenzo "indicates deposits formed in shallow lagunes near a coast line" and therefore he assumed that the continent had existed in that area. He did not discuss the regional distribution of the lagoonal facies, nor did he have sufficient data to recognize that it coincided in any marked degree with the distribution of the land mass he had outlined. This fact, set forth in preceding paragraphs, supports the view that widespread lagoonal conditions existed in southern and central Coahuila during Aptian time as the Cretaceous sea spread slowly northward across the southern peninsula of the North American continent. The land adjacent to these lagoons was low and furnished little clastic material to be deposited in them. Circulation was poor and evaporation kept their waters in a state of supersaturation permitting deposition of calcium sulphate and other salts. From time to time the sea-level was raised and flooded the lagoons with new supplies of normal sea water, or perhaps submerged them entirely, producing shallow, submarine banks. At these times calcium carbonate and magnesium carbonate were deposited and marine organisms which had not been able to live in the saline waters, temporarily flourished in the shoals bordering the open sea. Thus a series of deposits was built up consisting of gypsum interbedded with limestone and dolomite. The lithologic sequence of the Cuchillo formation admits of this interpretation of environment. Its areal distribution suggests that such an environment was related to the submergence of the Coahuila peninsula.

STRUCTURE

GENERAL STATEMENT

The structural pattern of southern Coahuila and eastern Durango falls naturally into three divisions: (1) a central belt of broad, gentle folding which extends from Sierra de la Paila, Coahuila, on the east,

[19] Emil Böse, *op. cit.* (1923), p. 134.

to the Sierra de Campana, Durango, on the west, and from Sierra de García on the south northward into central Coahuila; (2) a belt of strong folding in eastern Coahuila, northeast of Sierra de Alamitos and southeast of Cuatro Ciénegas; and (3) a belt of intense deformation which extends across southernmost Coahuila and northern Zacatecas from eastern Durango on the west to central Nuevo León on the east.

CENTRAL PROVINCE

The central belt of broad gentle folding includes the great brachyanticlines or periclinal folds of Sierra de la Paila, Sierra de Alamitos, and Sierra de García in the east (Fig. 3). It also includes Sierra del Venado, Sierra del Sobaco, Sierra de Tlahualilo, Sierra de Campana, and related ranges in the west. Undoubtedly it takes in many mountain ranges lying north of this western group, but they have not been studied in sufficient detail to demonstrate the regional structural plan.

The structure of the Cretaceous rocks in the mountains bordering the valleys of Las Delicias and Acatita illustrates the type of folding characteristic of the central province. Kelly[20] and Robinson[21] have studied these ranges in some detail. The major structure of the ranges between the two valleys is a broad, composite, anticlinal uplift trending northwest and southeast and plunging in both directions. Superimposed upon it are many sharp, persistent folds parallel with the central axis. Minor cross folds, ordinarily non-persistent and with gentle dips, appear to reflect topographic irregularities in the basement rocks. The central axis of the major anticlinorium extends along the western margin of the range in the northwestern part of its extent, but at the southeast it crosses the central part of the mountain area. Limited observation on the minor anticlines southwest of this axis indicates that they tend to be asymmetrical with the steeper dip on the southwest.

EASTERN PROVINCE

The eastern belt of strong folding which lies northeast of the Central Province is arbitrarily limited for the present discussion to the mountain ranges lying southeast of Cuatro Ciénegas and west of the railroad from Monclova to Paredón. The railroad in this stretch touches the eastern margin of the state of Coahuila. This province includes Sierra de la Fragua, Sierra de San Marcos, Sierra de la Purísima, and parallel ranges on the northeast. On the southeast it includes Sierra de Rosalia, Sierra de Patula, and Sierra de la Gavia.

[20] W. A. Kelly, *op. cit.*

[21] W. I. Robinson, manuscript.

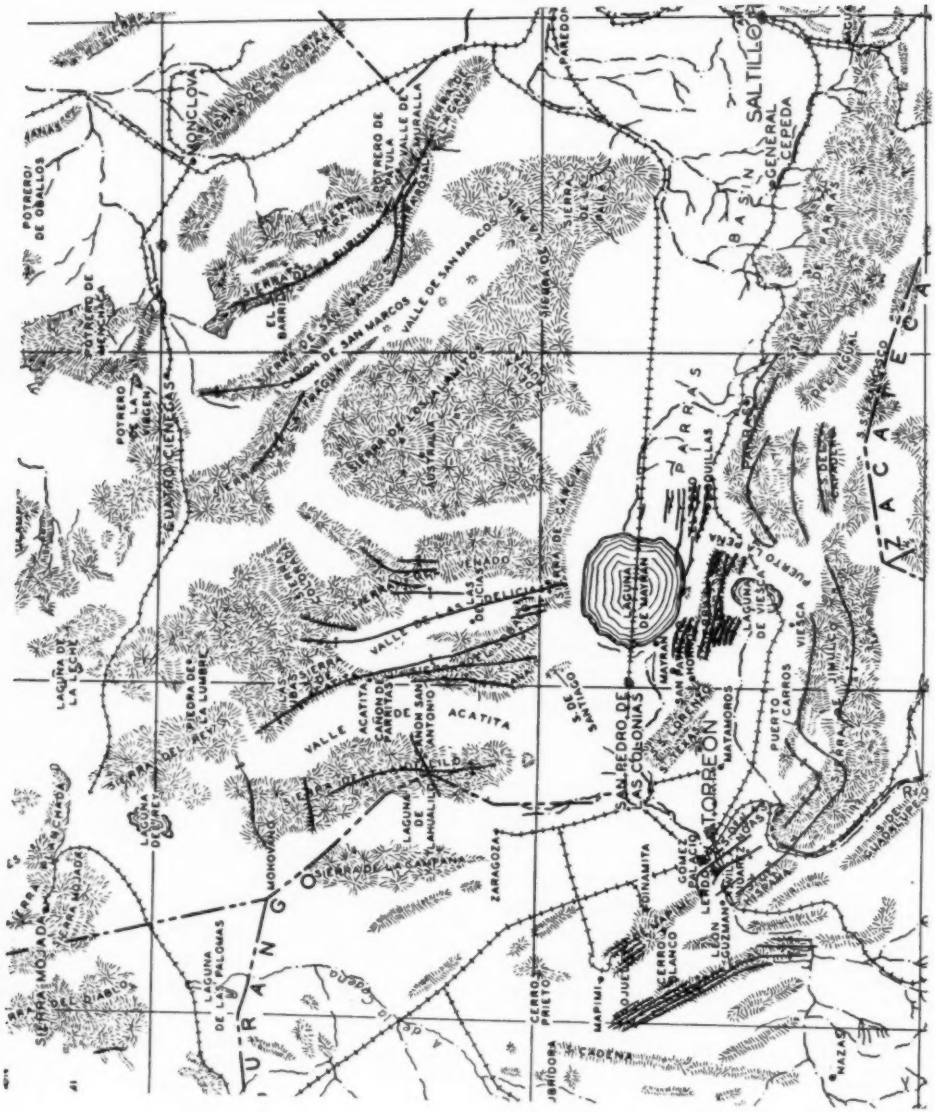


FIG. 3.—Structural trends in southern Coahuila and eastern Durango.

These are the principal ranges south of Monclova (excepting Sierra de la Gloria) which lie west of the Upper Cretaceous geosyncline extending northward through Paredón—a continuation of the Parras basin. This province is characterized by long, steeply folded anticlines which trend northwest approximately parallel with the northeast flank of Sierra de Alamitos. The folds are asymmetrical and in most cases have their steeper flank on the southwest. Erosion along the axes has commonly formed anticlinal valleys at places along the crests. Sierra de la Purísima, with the valley of El Barril at one point along the axis, may be cited as a typical example of the type of folding in this province. The beds along the southwest flank are approximately vertical, while those on the northeast dip away at a comparatively low angle. Thus the axial plane dips northeastward. The highest and most rugged part of the mountain range is formed of Lower Cretaceous limestone, but along the western flank remnants of basal Upper Cretaceous shales and thin-bedded buff limestones are locally present. In the valley of El Barril arkose and coarse conglomerates of the Neocomian are well exposed.

SOUTHERN PROVINCE

A pronounced zone of cross-folding in the Sierra Madre Cordillera has a width of about 75 miles and has been traced for more than 250 miles from the state of Durango on the west across southern Coahuila, northern Zacatecas, and Nuevo León into Tamaulipas on the east. It forms a salient in the eastern front of Sierra Madre Oriental south of Monterrey and is reflected in the structure of the San Carlos Mountains of Tamaulipas 30 miles east of the cordilleran front. This zone is divided into two physiographic and structural subprovinces: (1) the Parras basin on the north, and (2) a belt of high mountain ranges on the south. The former is a geosyncline, the latter a geanticline, both with innumerable minor anticlines and synclines superimposed.

Sierra de Parras, in southern Coahuila, near the center of the southern province and at the northern edge of the mountain subprovince, is fairly representative. It has been studied and mapped in considerable detail by R. W. Imlay.[22] From the town of Parras westward to Puerto La Peña, a distance of 30 miles, the range comprises five principal anticlines which are the northern folds of a broad anticlinorium. All the anticlines are overturned toward the north and locally some of them are also overturned toward the south, producing

[22] Ralph W. Imlay, "Geology of the Western Part of Sierra de Parras, Mexico," *Geol. Soc. America* (in press).

fan-shaped folds in a very limited part of their extent. Toward the west end of the range the trend of the axes turns rather sharply from northwest to southwest, and concomitantly the folds are more strongly compressed and their axial planes are more inclined. In the westernmost 3 miles the folds are nearly recumbent and are overthrust at least ½ mile toward the northwest.

East of the town of Parras, the folds comprising the range become more numerous. New folds arise either (1) as flexures on the less disturbed flanks of overturned anticlines, or (2) within synclines, or (3) on the north side of the Sierra. Five major anticlines appear *en échelon* on the north side of the Sierra so that the trend of the northern front is more nearly east than the general trend of the folding. The northernmost anticlines of the Sierra de Parras, fronting the Parras basin, are always steepest on their north flanks, and in most places are strongly overturned. The anticlines within the Sierra are overturned toward the north, or south, or are fan-shaped. There is no apparent system in direction of overturning. Along the trend of some anticlines the direction of overturning changes at intervals ranging from 5 to 10 miles. Some anticlines are locally overturned toward both north and south, thereby producing fan-shaped folds. The highest structural uplift of the entire Sierra occurs in the northernmost range south of General Cepeda, and the oldest rocks exposed, probably as old as in a similar structural high near the western part of the Sierra, are Oxfordian.

The axes of folding are rather sharply bent at several places. All these bends are occupied by cross-canyons which evidently were eroded along fracture zones. It is likely that some of the cross-canyons mark the position of cross-faults.

FORELAND CONTROL OF STRUCTURE

The Coahuila peninsula is regarded as the chief cause of the prominent zone of cross-folding which lies south of it extending across southern Coahuila and northern Zacatecas. The peninsula acted as a foreland which failed to compress with the surrounding sediments because of its more resistant substructure. Evidently the tangential pressure which shortened the strata of the cordilleran trough as a whole east and west, acted from the west, the east, and the south against the peninsula. The thrust was from the sea toward the continent. As the peninsula was bordered on three sides by the sea, there is a tendency for the overturned or steeper flank of the marginal folds to be toward the peninsula on each side.

The structure of Cretaceous rocks on the Coahuila peninsula and

their relation to the intensely folded marginal belt is strikingly similar to the Alpine forelands of Europe in their relation to the mountain chains of the Alpine type. In central Spain, for instance, the Celt-Iberian block is bordered by the Pyrenees on the north and the Betian chains in the south, which belong to the Alpine system. On the Celt-Iberian foreland block itself the direction of the asymmetries is predominantly north in the northern part of the block and predominantly south in the southern part. In the marginal zone of Alpine folds, however, the southern Pyrenees are overturned toward the south against their southern borderland (the foreland block) and the Betian chains are folded over toward the north. Thus the strong asymmetries of the mountain chains of the Alpine type toward the Celt-Iberian foreland are contrasted with more subdued asymmetries within the Celt-Iberian block toward the fringing folded mountain chains.[23]

This parallelism between the Coahuila peninsula and the foreland of central Spain is so evident as to indicate a similar origin.

GEOLOGIC HISTORY

The first period of diastrophism which can be recognized in southern Coahuila is correlated with the Appalachian revolution. This is demonstrated by the steep folding of the Permian and other Paleozoic rocks. Outpourings of lava and intrusions of granodiorite associated with the Paleozoic sediments in the foreland block are regarded as a phase of the same orogenic disturbance.

In mid-Jurassic or Triassic time volcanic activity occurred in the marginal seas southwest of the peninsula and deposited the red lavas now exposed in the Nazas valley at the center of the Villa Juárez uplift.

Submergence of the Coahuila peninsula in Aptian time was probably not accompanied by local diastrophism, for there were almost no clastic sediments laid down at that time and the thick gypsum deposits which accumulated indicate prolonged lagoonal conditions in an area which was very gradually sinking beneath the sea.

The second major period of diastrophism is correlated with the Laramide revolution. It began in early Upper Cretaceous time with emergence of most of Coahuila, Chihuahua, Durango, and Zacatecas. Concomitant with this regional upwarping was a slow subsidence of the Parras basin trough along the south side of the earlier foreland block, and subsidence in the northward continuation of the same

[23] Hans Stille, "Asymmetric Folds with Reference to German Salt Bodies," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 16, No. 2 (1932), pp. 171–73.

trough along the east side of the foreland. As relief of the land increased on either side of this narrow Upper Cretaceous embayment, active stream erosion channeled the newly exposed land surface. The streams in some places cut through the limestones which had been formed in the late stages of the Lower Cretaceous and widened their channels in the underlying shale formation. In these valleys gravel deposits were formed. They were composed chiefly of limestone cobbles from the formation through which the streams were cutting, but to a smaller extent they were made up of sandstones and red lavas from formations underneath the Lower Cretaceous limestone. At the close of the Upper Cretaceous (Maestrichtian) the sea withdrew entirely from the Parras basin trough and the entire cordilleran province was elevated above sea level. Intense folding then took place during the Eocene. The geosyncline of pre-Aptian time was now plicated into sharp anticlines and synclines, local isoclines, fan-folds, and overthrust faults. The gravel deposits which had accumulated in the valleys of the previously emerging land were folded with the Lower Cretaceous limestones and older rocks or, locally, were pushed up on edge by the advancing block of an overthrust fault.

This stage of compression was closely succeeded by the intrusion of granites, syenites, diorites, dacites, granodiorites, et cetera, in the form of stocks and laccoliths. Associated with them are dikes and sills of porphyrites, andesites, and alkali lamprophyres. Next followed a period of contraction in the earth's crust that gave rise to normal faulting in the mid-Tertiary, probably continuing into Quaternary time. Stream erosion stimulated by renewed elevation and relief spread coarse gravels along the stream courses. The last orogenic disturbances brought about renewed volcanic activity in the early Pliocene. Quantities of molten rock rose along faults and joints and poured out on the surface. Volcanic tuffs and breccias were widely distributed over the intermontane valleys, followed by lavas, first predominantly rhyolites and subsequently basalts. As the igneous activity subsided and the forces of denudation continued to operate, land forms resulting from the orogeny were severely modified, fault scarps gave way to fault-line scarps, mountain fronts receded irregularly, and the piles of volcanic debris were dissected into isolated remnants. Some warping of the crust continued even after the last outbursts of lava. In the present arid climate, most of Coahuila, Chihuahua, and Durango is characterized by interior drainage which has converted the valleys into broad, alluvium-filled, intermontane bolsons.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 20, NO. 4 (APRIL, 1936), PP. 433-456, 2 FIGS.

MICROPALEONTOLOGY IN MEXICO WITH SPECIAL REFERENCE TO THE TAMPICO EMBAYMENT[1]

REGINALD WRIGHT BARKER[2]
Tampico, Tamps., Mexico

ABSTRACT

This article is a brief historical summary of micropaleontological work in Mexico followed by a discussion of methods employed and short notes on the character of the various faunas.

INTRODUCTION

This article has been prepared through the kindness of E. A. Ritter, chief geologist of the Aguila Company, and is published with the permission of the Bataafsche Petroleum Matschappij. The writer wishes to express his thanks to them and also to W. H. Hegwein, of the Aguila Company, for reading the manuscript and for several helpful suggestions.

It is proposed to give a brief account of the progress of micropaleontology in Mexico, showing at the same time how the various steps seen in the general progress of the science may be followed in a restricted area.

HISTORICAL SUMMARY

The application of micropaleontology to subsurface geology began comparatively late, and probably Mexico was one of the first countries where such work was attempted on a scientific basis. From information supplied by John M. Muir it appears that Dumble had begun to see the possibilities of this method of investigation as early as 1916 in connection with petroleum work in Texas, and in 1917 some Mexican material had been sent through his agency to Joseph A. Cushman. In so far as micropaleontology was attempted on a large scale it may be said to have begun in 1920, when T. Wayland Vaughan undertook a survey of the eastern part of Mexico, for the Aguila Company. The numerous marl and shale samples collected during this work were sent to Cushman, who prepared a report on the smaller *Foraminifera* found, the whole work being undertaken on the condition that no results were to be published before the spring of 1924 without obtaining special permission. Bearing this in mind, and also realizing that work on the Mexican collections was continuing steadily, we can under-

[1] Manuscript received, December 28, 1935.

[2] The Aguila Company.

stand the flood of papers on Mexican *Foraminifera* which began in 1925. From 1925 to 1927 Cushman published 10 papers dealing with Mexico and 7 or more others containing references to new species from the Mexican Tertiary and Upper Cretaceous.

These papers were all more or less "biological" in that they dealt with species as species rather than as fossils aiding in the solution of stratigraphical problems. No good account of the Mexican Tertiary and Upper Cretaceous had appeared since the very generalized summary of Dumble in 1918 (48),[3] and the subdivisions of the Tertiary were in a state of confusion. Dumble gives the divisions Chicontepec and Alazan as the only Eocene formations and the Meson, San Rafael, and Tuxpam as the Oligocene. At the time of Vaughan's work the Tantoyuca was also known, but the Aragon, Guayabal and Chapapote were not yet separated, nor was the age of the Alazan correctly understood. As a result the Eocene and some Oligocene species described were nearly all ascribed to either the Tantoyuca or Alazan or merely referred to a locality, with no reference to geological age. The most valuable of the early papers was undoubtedly the description of the Velasco *Foraminifera* (72) published in 1926, since it was the first attempt to give a complete survey of any Mexican foraminiferal fauna.

Notwithstanding their shortcomings, however, these early papers served as an excellent basis for future workers, and the new species so described have been incorporated, for the most part, in the series of papers published by W. Storrs Cole and W. L. F. Nuttall between 1927 and 1932. In this period we have a detailed survey of the Upper Cretaceous *Foraminifera* by Maynard P. White (59, 60), and part of the Eocene and Lower Oligocene faunas by W. L. F. Nuttall (88, 89). All these are based primarily on stratigraphy, the study passing from systematic to stratigraphical paleontology, faunas being described with reference to their geological age and associations rather than to their zoölogical classification. Thus we have in Mexico the first big stride to be made in micro-paleontology as applied to economic work.

With respect to the so-called "larger *Foraminifera*," Cushman completed a comprehensive preliminary survey of American forms in 1919–20 in his accounts of the genera *Lepidocyclina*, *Diccocyclina*, *Heterostegina*, and *Operculina*. Unfortunately, he based his species primarily on external characteristics, and with the multiplication of species since these papers were written, much confusion has arisen from this. In 1924 Vaughan endeavored to correct some of the earlier

[3] See Bibliography at end of article.

errors in his paper entitled "American and European Larger Tertiary Foraminifera" (94), and followed this with a large number of detailed studies of American larger *Foraminifera*, several of which dealt with Mexican material obtained during his survey of 1920 (95, 96, 97, 98).

At the present time we have, in the published work on Mexico, a large amount of descriptive data, and a reasonably satisfactory classification based on *Foraminifera*. But the final stage of micropaleontology, the study of vertical and lateral variation of fauna in relation to facies, has barely commenced. Cole, in his discussion of the Chapapote fauna (60), draws attention to the equivalence of the Chapapote to the Tantoyuca, the latter being the shallow-water facies of the former, and Nuttall, in a recent paper (91), notes the variation of facies in the Tampico Embayment Tertiary rocks, but beyond these references little has been published on this subject.

METHODS

Among the earlier accounts of micropaleontological methods is Edward Heron-Allen's "Prolegomena Towards the Study of the Chalk Foraminifera" (19), published in London in 1894.

In this paper we have a very good account of washing, separating, and mounting *Foraminifera*, and also a good method of obtaining thin sections of smaller *Foraminifera*. The technique is primarily that most suitable for detailed research work, however, and not until the publication of Cushman's "Foraminifera, Their Classification and Economic Use" in 1928, has there been a concise account of the best methods for economic work.

Work in Mexico commenced with the usual somewhat haphazard identification of species from the limited literature available, a procedure always attended by the disadvantage that later workers are often in doubt as to the real identity of the species intended. This was followed by the adoption of a system based in part on the suggestions of Cushman, but developed independently by various workers. A brief but clear account of this has been given by Nuttall in the *Proceedings* of the World Petroleum Congress held in London in 1933, in a paper entitled "The Application of Micropalaeontology to Petroleum Geology," and a more detailed description in a later paper by Franz Hecht (17).

The principal points to be observed are as follows.

1. The suitable washing of the shale and clay samples, taking into consideration the necessity for speed, and care in avoiding the loss or breakage of smaller and more fragile forms.

2. The picking of the samples, with a view to obtaining a figure of the "quantitative occurrence" of the various species. Complete separation of all the *Foraminifera* from a sample is a very tedious process and is rarely necessary, though it may be ad-

visable when commencing to study a new area. There is always the possibility that minute forms may be missed, and also loss or damage of specimens in transferring them. As a quantitative check in comparing two faunas, a method has been suggested whereby the theoretical number of occurrences of any species in a hundred samples from the same horizon is calculated and compared with the figure obtained for the same species from a second horizon.

3. The selection of a type section for any basin of deposition, and the building up of a collection of "types" is essential in economic work, since, although the process is slow at the beginning, it greatly speeds up the work in its later stages, and enables a newcomer to grasp very rapidly the essential points in correlation in that particular area. The term "type" is used here, in a restricted sense, for the species occurring in any basin of deposition, the species being designated at first by numbers. This is described by Cushman in both editions of his text-book. Later it may be advantageous to proceed with the identification of the various "types" from the literature, and at the same time to build up a card-index of all the more important species with morphological descriptions, photographs or drawings, and notes on their ranges.

In connection with this point it may be mentioned that in Mexico it has not been found necessary to consider the entire fauna of any formation for economic work, approximately 400 species being sufficient for the entire succession from the Upper Cretaceous to the Miocene, in the Tampico Embayment area. The fewer species involved in economic work the more rapid the determinations, and hence, the most important point in commencing work is to restrict observations so far as possible to the commoner species and to those of restricted vertical range with wide distribution. This, naturally, can be determined only by extensive study in the first place, but should be borne in mind, to avoid much loss of time in the preliminary studies.

4. The conditions affecting distribution should be carefully considered, apparent changes in fauna being compared with changes in lithologic character, and the possibility of change in facies rather than change in horizon should not be neglected.

5. In recording results it has been found more satisfactory to list the principal *Foraminifera* occurring in every sample, by comparison with the types already referred to, rather than to compare each sample with a type faunal assemblage. The advantage of this lies in the fact that any assemblage collected from a type locality, unless based on a very large number of samples, contains only a selection of the typical forms, and only rarely is it possible to find identical assemblages in single samples from different outcrops of the same horizon. Thus instead of having to compare the fauna of a sample with a "type assemblage" of any formation containing perhaps 50 or 100 species, many of them rare, we have only to look for a half dozen or less species which experience has shown us to be restricted in range to that formation.

6. In the paper referred to earlier (91) Nuttall stresses one of the most important points in petroleum geology, and one which is frequently ignored. That is, the necessity or advisability, of considering any basin of deposition as an individual problem, without endeavoring to correlate with distant areas, as experience has shown that the distribution of the smaller *Foraminifera* may differ widely in neighboring regions.

This point is especially applicable to Mexico, since work has shown it well-nigh impossible to correlate the local micropaleontological zones of the Tampico Embayment with either those of the Gulf Coast area of the United States, or with those of the Isthmus Embayment, and Chiapas and Tabasco. The changes in facies so affected the faunas that no detailed correlation in the areas in question can be attempted until the surface geology is known in considerably greater detail.

For a knowledge of the principal literature dealing with micropaleontological technique, reference may be made to the bibliography given in the second edition of Cushman's textbook, and to the list appended to the present paper.

7. A very important point to be noted is the necessity for studying the larger *Foraminifera* by means of thin sections. Several notes have been published on this subject (20, 25, 33, 37 and 38), but the best method for economic work, in the writer's experience, is that given by Dickerson and Van der Vlerk in the *Journal of Paleontology*, in Volume 1, Part 3 (1927). In this account the use of a small whetstone is advised, and the Mexican larger *Foraminifera* have been studied in this way, using a fine-grained whetstone, a spirit lamp, and a tube of Canada Balsam, the whole outfit being kept on a tray, and of such portability that sections may be made anywhere. For comparisons photographs are invaluable, and the most convenient method has been found to be the old one of a petrological microscope used in connection with a long camera bellows, fitted with an adaptor for the use of filmpacks (Fig. 2). By this means films

of fine grain, specially sensitive to artificial light, may be used, and a large number of photographs may be taken in a very short time, the old disadvantage of changing plate-holders in a dark room being avoided. It is found that by this method no dark room is necessary, as a negligible amount of daylight enters through the small microscope objective, yet a beam of light directed through the section, onto the film, enables good photographs to be taken with exposures of less than one second. Magnifications up to 180 diameters may be taken with comparatively short exposures, and the use of film has the additional advantage of considerably greater latitude than most plates.

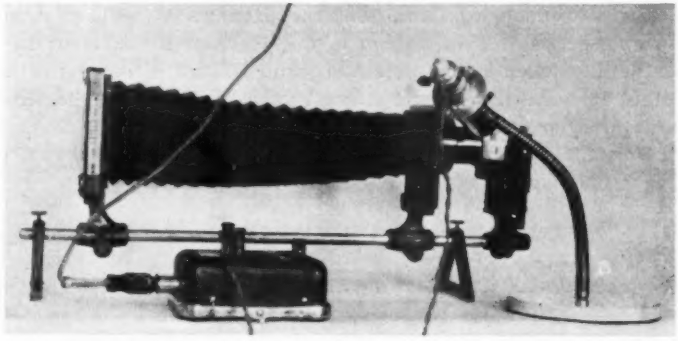


FIG. 1.—Zeiss camera, with Tessar F. 4.5 lens (f-2 cm.) set up to take photographs of smaller *Foraminifera*, without use of microscope. Specimens are mounted on slide with black background, and adjusted by means of mechanical stage.

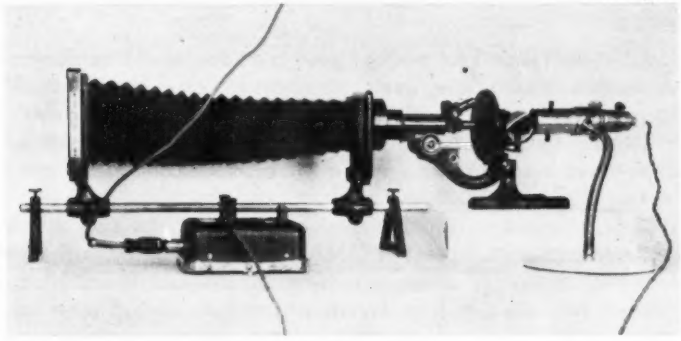


FIG. 2.—Bellows of Zeiss camera, as used in conjunction with petrological microscope, objective of microscope serving as camera lens. This method is used for thin sections of larger *Foraminifera*.

MEXICAN MICROFAUNAS

It is now proposed to follow a general outline of the methods employed, and their development, by short notes on the results so far obtained by those methods in the Tampico Embayment area. This

region, by reason of its petroleum production, has received more attention than most areas of Tertiary sedimentation, and the richness of its microfaunas in conjunction with the paucity of macrofossils renders it an excellent example of the value of *Foraminifera* in geological classification.

A table prepared by W. L. F. Nuttall for the World Petroleum Congress (London, 1933), showing the distribution of the more important species of *Foraminifera* in the Tampico Embayment area, has been included in the present account by kind permission of the author (91). It will be found of great value in amplifying the necessarily brief notes on the faunas given in the succeeding pages.

The published stratigraphical column in the Tampico Embayment area is as follows.

Lower Miocene		Túxpam formation
Oligocene		Mesón Upper Alazán Lower Alazán
Eocene	Upper	Upper Chapapote Lower Chapapote-Tantoyuca
	Middle	Guayabal (Tempoal)
	Lower	Aragón
Paleocene[4]		Chicontepec Velasco
Cretaceous (Upper)		Mendez

All these formations contain good microfaunas where they are developed as marls, shales, or clays, and the succession may be readily determined by means of the *Foraminifera*. Most of the formations show sandy development in places, but generally there is sufficient of the shale facies present to allow the determination of the age in any exposure.

It is proposed to treat each of these formations very briefly, from a paleontological point of view. As the stratigraphy, with a full discussion of type localities, priority of nomenclature, and similar points, is published by John M. Muir,[5] it is not touched upon here.

TÚXPAM FORMATION

As the Túxpam is a shallow-water transgressing formation, the beds, for the most part, consist of conglomerates and shell beds with calcareous cement, interbedded with sandstones and sandy marls, and the microfauna is poor, and commonly contaminated with

[4] For discussion on use of the term Paleocene see page 443.

[5] John M. Muir, *Geology of the Tampico Region, Mexico* (Amer. Assoc. Petrol. Geol., in press).

derived species. *Cristellaria vaughani* Cushman and *Rotalia beccarii* (Linné) var. are the most important species, and where present are considered diagnostic of the formation (48, 53, 54, 58, 125, 129).

MESÓN FORMATION

The Mesón, also, is a predominantly shallow-water series, but with a greater proportion of marls, usually very sandy. The macrofauna is very rich in places, owing to the development of a coral-reef facies, but the microfauna is notably variable. In places it is rich, and contains many species also found in the underlying Alazán, but toward the south a sandier facies predominates and the fauna is scanty, many individuals being dwarfed. Distinction from the overlying Túxpam is readily accomplished, but the separation from the underlying Alazán depends in some places on negative evidence such as the absence of typical Alazán species. Throughout the northern part of the Tampico Embayment are beds rich in *Lepidocyclina* and *Heterostegina*, most of the species being restricted in range. Among the microforaminifera *Marginulina mexicana* Cushman and several species of *Discorbis* and *Cibicides* are generally common. The fauna of part of the Mesón has been discussed by Cole and Gillespie (61), but the material examined was inadequate for a general survey of the fauna (48, 53, 54, 56, 61, 66, 84, 90, 91, 92, 94, 98, 120).

ALAZÁN FORMATION

In general, deeper-water conditions prevailed in later Alazán time. The early beds, with numerous species of *Lepidocyclina*, show faunas believed to indicate deposition in warm seas of moderate depth, probably equivalent to the higher portion of the continental shelf. The fauna has been described by Nuttall (89) and shows a number of species in common with the Vicksburg formation of the United States. *Nodosaria*, *Cibicides*, *Planulina*, *Cristellaria*, *Vaginulina*, *Pleurostomella*, *Vulvulina*, *Textularia*, and *Gaudryina* are the commonest genera and the fauna as a whole is rich in large and well preserved species. The most important species for distinguishing the Lower Alazán from the upper division are the following.

Anomalina grosserugosa (Gümbel)
Cibicides cushmani Nuttall
Cibicides mexicana Nuttall
Cibicides perlucida Nuttall
Cibicides tuxpamensis Cole
Vulvulina spinosa Cushman
Vaginulina elegans d'Orbigny var. *mexicana* Nuttall

The Upper Alazán shows deeper water deposition with a predominance of species of *Uvigerina*. *Uvigerina alazanensis* Nuttall, *U. pig-*

maea d'Orbigny, and related forms are commonly so numerous as to mask the remaining species. In company with these are numerous small species, for example, *Rectobolivina mexicana* (Cushman), *Bolivina tongi* Cushman, *Clavulina alazanensis* Nuttall, large numbers of *Bolivina mexicana* Cushman and its varieties, and *Planulina mexicana* Cushman. The fauna of the Upper Alazán is remarkable for the excellent state of preservation of the fragile specimens, and for the richness in individuals. Most of the commoner and more conspicuous forms have been described and figured by Cushman and Nuttall (67, 68, 69, 73, 75, 77, 78, 89, 98. For stratigraphy see also 48, 53, 57, 83, 125, 129).

CHAPAPOTE FORMATION

The Chapapote formation was confused by early workers with Dumble's Alazán and many of the species described by Cushman as occurring in the Alazán belong in reality in the Chapapote of Cole, which is Jackson in age. The Chapapote has been divided into an upper and a lower division by Nuttall (91), though no description of the two members has been published. The upper division, of slightly shallower water facies than the lower, consists of gray marls, in places interbedded with sandy marls and here and there thin sandstones. It may be separated from the overlying Lower Alazán by the presence of *Anomalina dorri* Cole, *Rotaliatina mexicana* Cushman, and other less important forms. The underlying Lower Chapapote is readily distinguished by the presence of *Hantkenina* spp. (including *H. alabamensis* Cushman) and *Pulvinulina cerroazulensis* (Cole), which do not occur in the upper beds.

The fauna in the Lower Chapapote is a rich one, the formation consisting of fine-grained gray marls which, on washing, yield a large residue entirely made up of *Foraminifera*, principally species of *Globigerina*. The fauna and lithologic character, both remarkably uniform over wide areas, indicate deposition in deep, still water, and there is a sharp separation from the overlying Alazán.

The important features in the fauna are the enormous numbers of specimens of *Globigerina* (referred by Cole and Nuttall (60) to *G. inflata* d'Orbigny, *G. mexicana* Cushman, and *G. bulloides* d'Orbigny) and the occurrence of several species of *Hantkenina*. The latter are considered to be important criteria in distinguishing the Eocene from the Oligocene, and in the Chapapote are *H. alabamensis* Cushman, *H. longispina* Cushman, and less commonly *H. danvillensis* Howe and Wallace (60, 62, 63, 78, 88).

TANTOYUCA FORMATION

The Tantoyuca was considered at first to be a separate formation, but has since been traced laterally into the Lower Chapapote, of which

it is regarded as the near-shore equivalent (60, p 4; 88, p. 273). This correlation is supported by the lithologic character since the beds are in many places sandy and conglomeratic, and also by the fauna, which is poor in pelagic species, and rich in such shallow-water forms as *Operculina* and *Lepidocyclina*, and also contains derived Guayabal species at many localities. The characteristic Chapapote species, *Hantkenina alabamensis*, *Globigerina inflata*, and *Pulvinulina cerroazulensis* (Cole), generally occur, also *Cristellaria texasensis* Cushman and Applin, *Operculina willcoxi* (Heilprin), *O.* cf. *mariannensis* Vaughan, and various species of *Lepidocyclina*.

GUAYABAL (TEMPOAL) FORMATION

The lithology of the Guayabal formation, as described by Storrs Cole, from near the village of Guayabal, in the Hacienda Tamatoco, Veracruz, is characteristic and the formation has a rich microfauna. Ver Wiebe published the name Tempoal, for the same formation, in 1924, three years before Cole's use of the term Guayabal, but no description of the fauna from the Tempoal type locality has been published, and, moreover, the locality is situated in an area of greatly disturbed tectonics. It is, therefore, very unfortunate for the micropaleontologist that the name Tempoal has priority (Dorr, 46). The beds exposed at Guayabal show very well the characteristic chocolate brown marls, with the development of ironstone concretions and selenite crystals on the weathered surfaces, and on washing yield a rich fauna, typical of these beds throughout the embayment.

Among the more important species are: *Nodosaria mexicana* Cushman, *Eponides guayabalensis* Cole, *Cristellaria mexicana* (Cushman), *Ceratobulimina eximia* (Rzehak), *Discocyclina perpusilla* Vaughan, and several species of *Globorotalia*. The exposure at Tempoal probably represents a lower horizon, and shows some difference in the fauna, which is by no means as rich as that at Guayabal. Discussion of the stratigraphy may be found in papers Nos. 46, 59, 88, 91, in the bibliography at the end of this paper, and the most important papers dealing with the fauna are those by Cole, Cushman, and Nuttall (59, 65, 88).

ARAGÓN FORMATION

The beds underlying the Guayabal in the southern part of the Tampico Embayment have been given the name Aragón formation by Nuttall (88, p. 278), and the fauna is described in the same paper. The fauna as a whole shows slight resemblance to either the Guayabal or the Chicontepec, since it is of deep-water facies, with large numbers of pelagic *Foraminifera*—for example, *Globigerina* and *Globorotalia*. Deep-water deposition is shown lithologically by the fine grain and

general uniformity of the marls composing the formation and the very slight variation of the formation in different localities, either on the outcrop or in wells.

The principal species of value in determining the Aragón are *Globorotalia aragonensis* Nuttall, *Hastigerinella eocaenica* Nuttall var. *aragonensis* Nuttall, *Anomalina dorri* Cole var. *aragonensis* Nuttall, and *Hantkenina mexicana* Cushman var. *aragonensis* Nuttall. These have been described and figured by Nuttall in the paper already mentioned. In general the fauna is very rich in individuals, though poorer in species than the Oligocene Alazán. The smaller species are obscured by the enormous numbers of *Globigerina*.

CHICONTEPEC FORMATION

The Chicontepec formation was described and named by Dumble in 1918 (48), the presence of local conglomerates and massive beds of sandstone, interbedded with sandy marls, indicating a marine transgression and deposition in shallow water. The microfauna is poor, and most of the species are found also in either the Aragón or in the underlying Velasco. *Cornuspira* spp., *Bulimina elegans* d'Orbigny, and *Globorotalia velascoensis* (Cushman) are of common occurrence. A larger number of Velasco species are found near the base of the Chicontepec. Distinction of the Chicontepec beds from those above and below depends very largely on negative evidence, namely, the absence of key forms of other horizons. Vaughan has described three species and a variety of *Discocyclina* from the Chicontepec (95), thus fixing the Eocene age of the formation, though the species are of little use in correlation on account of their rarity (48, 53, 95).

VELASCO FORMATION

The microfauna of the Velasco has been dealt with very fully by White (99), many of the indigenous species having been previously described by Cushman (64, 72). The fauna and lithologic character indicate deposition in deep water for the most part, though sandy beds are present. *Flabellina delicatissima* Plummer, *Frondicularia elongata* White, *Bolivina decorata* Jones var. *delicatula* Cushman, *Bolivinoides velascoensis* (Cushman), *Anomalina velascoensis* Cushman, and large numbers of *Globorotalia velascoensis* Cushman characterize the average Velasco sample. The age of the Velasco is still a matter of controversy, though from a micropaleontological point of view it seems that an important faunal break occurs between the Mendez, which is undoubtedly Upper Cretaceous, and the Velasco, and that the latter is Paleocene.

It would perhaps be preferable to term the Velasco "Eocene-

Cretaceous transition beds," but this implies rather more than the evidence justifies. The term Paleocene can not be applied to the Velasco only, in Mexico, since that would not be in accordance with the definition of the term.

Paleocene, orginally used for continental deposits by Schimper in 1874, has been used by Grabau (*Text Book of Geology*, 1921) to include the Montian, Thanetian, and Ypresian. Morley Davies (*Tertiary Faunas*, Vol. II (1934), tables, pp. 230–31) includes only the Montian and the Thanetian, and considers the Midway as representing the Paleocene in the Gulf Coast Tertiaries of the United States. The term has been defined by W. D. Matthews in "Status and Limits of the Paleocene" (*Bull. Geol. Soc. America*, Vol. 31, p. 221; 1920), but the limits are not clearly stated, beyond noting that the European Cernaysian is included.

If we make use of the term "Paleocene" in Mexican stratigraphy, we must also include the Chicontepec. Although this is not in accordance with general usage, it seems to be the only method available which leaves the age of the Velasco as an open question. (For references to the Velasco, see 39, 43, 45, 51, 64, 72, 78, 81, 85, 99.)

MENDEZ FORMATION

The Mendez fauna has been described by White in his work on the Cretaceous of the Tampico Embayment cited previously, and a very large number of species of *Foraminifera* mentioned, and for the most part figured. Cushman (71) described some of the commoner species, which are still of great value as guides to the formation. These include *Globotruncana arca* (Cushman), *Cibicides excolata* (Cushman), *Bolivina incrassata* Reuss, *Planoglobulina acervulinoides* (Egger), *Pseudotextularia varians* Rzehak, and *Gümbelina excolata* Cushman. For further details regarding the fauna the reader is referred to White (99).

In general most of the species are pelagic and the assemblage shows a strong resemblance to that found in the European Upper Cretaceous. The state of preservation is rarely as good as in the Velasco, but the forms are so characteristic as to be readily recognized even when badly worn or recrystallized (51, 53, 71, 74, 78, 85, 99).

CONCLUSION

In conclusion, it may be pointed out that micropaleontology has developed in Mexico very much as the science as a whole has developed throughout the world. The Tampico Embayment provides an excellent example of the use of *Foraminifera* in economic work, the richness of the faunas aiding considerably in reaching a satisfactory

working section and at the same time providing many smaller problems of a research nature. The interrelation of faunas and facies is seen to be nicely balanced, and much yet remains to be done in elucidating the faunal changes from Texas to Yucatan, in their relation to facies, before we can arrive at a satisfactory correlation.

The southern part of Mexico, around Puerto Mexico, shows a great diversity of microfaunas, on which much work has already been done, and similarly, a succession based on *Foraminifera* has been built up in northeast Mexico. The ultimate aim will be to connect these various successions and so obtain a correlation throughout the entire Gulf Coast and Central America.

BIBLIOGRAPHY

In the course of work on Mexican paleontology, both with microorganisms and macro-organisms, a considerable number of references has been accumulated, principally from scattered articles in various periodicals. The most detailed work on Mexican stratigraphy to the present time is C. Burckhardt's monograph on the Mesozoic (43), but a further important contribution is the work of John M. Muir on the stratigraphy of eastern Mexico, previously mentioned.

For the benefit of those interested in micropaleontological technique and in the paleontology of Mexico, a selection of references which seem to the writer to be of most importance has been included in the present paper. The list is divided into sections, as it is believed that it is easier to consult and less cumbersome in this form. It must be borne in mind that the lists make no pretence to completeness, although the paleontological lists (III and IV) contain such references as the writer could find, after careful checking of numerous lists and bibliographies.

The following works will be found valuable for references to petroleum and mining in Mexico, and have been consulted in compiling the accompanying bibliography.

ANONYMOUS, 1927. "Bibliografía del Petróleo en México," *Departamento de Petróleo* (México, D.F.) *Monografías Bibliográficas Méxicanas*, No. 8, pp. 1–169.

AGUILAR Y SANTILLAN, RAFAEL, 1908. "Bibliografía Geológica y Minera de la República Méxicana," *Inst. Geol. Mexico Bol. 17* (later edition of *Bol. 10* by the same author), 330 pp.

———, 1918, "Bibliografía Geológica y Minera de la República Méxicana, 1905–1918," *Boletin Minero* (Mexico, D.F.).

I. LIST OF WORKS REFERRING ESPECIALLY TO MICRO-PALEONTOLOGICAL TECHNIQUE

1. BARNARD, J. E., 1914. "X-Rays in Relation to Microscopy," *Jour. Roy. Micr. Soc.*, No. 224, Pt. 1, pp. 1–7, Pl. i.

2. CARSON, CARLTON M., 1933. "A Method of Concentrating Foraminifera," *Jour. Pal.*, Vol. 7, p. 439.

3. CAYEUX, L., 1916. "Introduction á l'Étude Petrographique des Roches Sédimentaires," *Mém. Explic. Carte géol. dét. France*, 2 vols., pp. 1–524, i–x pls., i–lvi. Paris.

4. CULLISON, JAMES S., 1934. "A Suitable Tray for Comparative Examination of Minute Opaque Objects under the Binocular Microscope," *Jour. Pal.*, Vol. 8, p. 247.
5. CUSHMAN, J. A., 1924. "The Use of Foraminifera in Geologic Correlation," *Bull. Assoc. Amer. Petrol. Geol.*, Vol. 8, pp. 485–91.
6. ———, 1926. "Photographing Foraminifera," *Contrib. Cushman Lab. Foram. Research*, Vol. 2, pp. 1–3.
7. ———, 1926. "Some Phases of Correlation by Means of Foraminifera," *Contrib. Cushman Lab. Foram. Research*, Vol. 2, pp. 71–74.
8. ———, 1927. "Description of Foraminifera," *Jour. Pal.*, Vol. 1, pp. 13–14.
9. ———, 1928, 1933. *Foraminifera, Their Classification and Economic Use*, 1st edit., 1928; 2nd edit., 1933. See Chapters 2–5 and Bibliography at end. Sharon, Massachusetts.
10. DENNE, M. T., 1923. "An Improved Apparatus for the Production of Photomicrographs," *Jour. Roy. Micro. Soc.*, No. 263, pp. 157–62, Pls. iv–v.
11. DRIVER, H. L., 1928. "An Aid in Disintegrating Samples for Micro-Organic Study," *Jour. Pal.*, Vol. 1, pp. 253–54.
12. ELCOCK, C., 1882. "How to Prepare Foraminifera," *Jour. Postal Micr. Soc.* (Bath), Vol. 1.
13. FRANKE, A., 1922. "Die Präparation von Foraminiferen und anderen mikroskopischen Tieresten," in N. Keilhack, *Praktische Geologie*, Vol. 2, pp. 509–76.
14. ———, 1930. "Die Trennung der Mikrofossilien aus sandigen Schlämmrückständen mit Tetrachlorkohlenstoff," *Zeit. für Ges.*, Bd. 6, Heft 4, pp. 162–64.
15. HANNA, G. D., 1924. "Smaller Foraminifera for Stratigraphy," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 8, pp. 246–50.
16. ———, 1931. "Illustrating Fossils," *Jour. Pal.*, Vol. 5, pp. 49–68, Pl. viii.
17. HECHT, FRANZ, 1933. "Arbeitweisen der Mikropaläontologie," *Senckenbergiana*, Bd. 15, pp. 346–62.
18. HENBEST, L. G., 1931. "The Use of Selective Stains in Paleontology," *Jour. Pal.*, Vol. 5, pp. 355–64.
19. HERON-ALLEN, E., 1894. *Prolegomena towards the Study of the Chalk Foraminifera*, 36 pp., 8 figs. London.
20. HODSON, F., and H. K., 1926. "Short Cuts in Picking Out and Sectioning Foraminifera," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10, pp. 1173–74.
21. HOFKER, J., 1933. "A New Method of Making Slides of Foraminifera." In "Foraminifera of the Malay Archipelago," *Vidensk. Medd. fra Dansk Natur. Foren.*, Bd. 93, pp. 74–75.
22. LAMAR, J. E., 1929. "A Simple Accessory Stage for the Microscope," *Jour. Pal.*, Vol. 3, pp. 185–88.
23. LAUBY, A., 1909. "Nouvelle méthode technique pour l'étude paléophytologique des formations sédimentaires anciennes," *Bull. Soc. Botan. France*, Tome 56, Mém. 15, pp. 1–110.
24. MACFADYEN, W. A., and E. J. A. KENNY, 1934. "On the Correct Writing, in Form and Gender, of the Names of Foraminifera," *Jour. Roy. Micro. Soc.*, Vol. 54, pp. 177–81.
25. MURATA, K. J., 1935. "A Neglected Method for Making Thin Sections of Fossils," *Jour. Pal.*, Vol. 9, pp. 359–61.
26. NATLAND, MANLEY L., 1933. "The Temperature—and Depth—Distribution of Some Recent and Fossil Foraminifera in the Southern California Region," *Bull. Scripps Inst. Oceanography*, Tech. Ser., Vol. 3, No. 10, pp. 225–30; 1 table.
27. NORTON, RICHARD D., 1930. "Ecologic Relations of Some Foraminifera," *ibid.* Vol. 2, No. 9, pp. 331–88.
27A. NUTTALL, W. L. F., 1933. See No. 91.
28. PLUMMER, H. J., 1929. "Photographic Slide-Mount for Micro-Fossils," *Jour. Pal.*, Vol. 3, pp. 189–95.
28A. REED, R. D., 1931. "Microscopic Subsurface Work in Oil Fields of United States," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, No. 7, pp. 731–54 (see for further reference to papers in Bulletin).
29. REESIDE, JOHN B., JR., 1930. "The Preparation of Palaeontologic Illustrations," *Jour. Pal.*, Vol. 4, pp. 299–308, Pl. xxvi.
30. RIDGWAY, JOHN L., 1920. "The Preparation of Illustrations for Reports of U. S. Geological Survey," *U. S. Geol. Survey.*
31. SCHENCK, E. T., and J. B. MCMASTERS, 1932. "Recommendations for Procedure in the Description of a New Species," *Micropal. Bull.*, Vol. 3, No. 3, pp. 98–107.

32. SCHENCK, H. G., 1928. "The Biostratigraphic Aspect of Micropalaeontology," *Jour. Pal.*, Vol. 2, pp. 246–50.
33. SCHLUMBERGER, C., 1885. "Sur un procédé permettant d'exécuter des sections minces dans les foraminifères," *Feuille des Jeunes Naturalistes*, 15me. Année, No. 174 (Avril).
34. SECRIST, MARK H., 1934. "Technique for the Recovery of Paleozoic Arenaceous Foraminifera," *Jour. Pal.*, Vol. 8, pp. 245–46.
35. THOMAS, N. L., 1927. "The Uses of Evolutionary Changes in Geologic Correlation," *Jour. Pal.*, Vol. 1, pp. 135–40.
36. VAUGHAN, T. WAYLAND, 1924. "Criteria and Status of Correlation and Classification of Tertiary Deposits," *Bull. Geol. Soc. America*, Vol. 35, pp. 677–742.
37. VLERK, I. M. VAN DER, 1933. "The Task of the Oil Palaeontologist," *Geol. und Mijnbouw*, No. 2 (May), 4 pp., figs.
38. VLERK, I. M. VAN DER, and R. E. DICKERSON, 1927. "Distinctions among Certain Genera of Larger Foraminifera for the Field Geologist of the East Indies," *Jour. Pal.*, Vol. I, No. 3, pp. 185–92.

NOTE: Some interesting notes on the technique of sectioning may be found in C. O. Dunbar and G. E. Condra's monograph on "The Fusulinidae of the Pennsylvanian System in Nebraska" (*Nebraska Geol. Survey Bull.* 2, 2nd. Ser. (1927), pp. 1–135, Pls. i–xv).

II. List of Some of More Important Works Dealing With Mexican Stratigraphy

39. BELT, BEN C., 1925. "Stratigraphy of the Tampico District of Mexico," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 9, pp. 136–44.
40. BÖSE, EMIL, 1905. "Reseña acerca de la geología de Chiapas y Tabasco," *Inst. Geol. México Bol. 20*, pp. 1–116; 9 pls.
41. ———, 1923. "Vestiges of an Ancient Continent in Northeast Mexico," *Amer. Jour. Sci.*, ser 5; Vol. 6, pp. 127–36; 196–214; 310–38.
42. ——— and O. A. CAVINS, 1927. "The Cretaceous and Tertiary of Southern Texas and Northern Mexico," *Univ. Texas Bull. 2748*, pp. 1–142.
43. BURCKHARDT, C., 1930. "Étude synthétique sur le Mésozoïque mexicain," *Mém. de la Soc. Pal. Suisse*, Vols. 49 and 50, 280 pp.
44. BUSTAMANTE, MIGUEL, 1918. "El Petróleo en la Republica Méxicana (Estudio geológico economico sobre los yacimientos petróliferos Méxicanos)," *Inst. Geol. México Bol. 35*, 216 pp., maps.
45. CUSHMAN, J. A., and E. A. TRAGER, 1924. "New Formation in the Tampico Embayment Region," *Bull. Geol. Soc. America*, Vol. 35, p. 100.
46. DORR, JAMES B., 1930. "The 'Guayabal' Formation of Mexico," *Jour. Pal.*, Vol. 4, pp. 418–19.
47. DUMBLE, E. T., 1915. "Tertiary Deposits of Northeastern Mexico," *Proc. California Acad. Sci.*, 4th ser., Vol. 5, No. 6, pp. 163–93, Pls. xvi–xix.
48. ———. 1918. "Geology of the Northern End of the Tampico Embayment Area," *ibid.*, 4th ser., Vol. 8, pp. 113–56, Pls. iii–vi.
49. HOVEY, OTIS E., 1907. "A Geological Reconnaissance in the Western Sierra Madre of the State of Chihuahua, Mexico," *Bull. Amer. Mus. Nat. Hist.*, Vol. 23, pp. 401–42, Figs. 1–13, Pls. xviii–xxxv, map.
50. HUNTLEY, STIRLING, 1923. "Oil Development in the Isthmus of Tehuantepec," *Trans. Amer. Inst. Min. Met. Eng.*, Vol. 69, pp. 1150–66.
51. MORGAN, HENRY J., JR., 1931. "The Velasco-Mendez Contact in the Vicinity of the Ebano Field, Mexico," *Jour. Pal.*, Vol. 5, pp. 42–47.
52. MÜLLERRIED, F. K. G., 1930. "Informe preliminar de la exploración geologíca del Estado de Chiapas, durante los años de 1927, 1928 y 1929," *Inst. Geol. México Folleto de Divulgación 36*, pp. 1–16.
53. PALMER, R. H., 1927. "Geology of Eastern Hidalgo and Adjacent Parts of Veracruz, Mexico," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 11, pp. 1173–1220.
54. STAUB, WALTHER, 1928. "Über die Verbreitung der Oligocänen und der alterneogenen Schichten in der Golfregion des nordöstlichen Mexiko," *Eclogae Geol. Helvet.*, Vol. 21, pp. 119–30.
55. TATUM, J. L., 1931. "General Geology of Northeast Mexico," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, pp. 867–93.
56. THALMANN, HANS E., 1934. "Mitteloligozän in der Umgebung von Tampico (Mexiko)," *Geol. Rundschau*, Bd. 25, pp. 325–29.

57. VER WIEBE, W. A., 1924. "The Stratigraphy of the Petroliferous Area of Eastern Mexico," *Amer. Jour. Sci.*, 5th ser., Vol. 8, pp. 277–95, 385–94, 481–502.
57A. ———, 1925. "Geology of Southern Mexico Oil Fields," *Pan-Amer. Geol.*, Vol. 44, pp. 121–38; 2 pls.
58. WOODRING, W. P., 1928. "Miocene Mollusks from Bowden, Jamaica, Pt. II, Gastropods and Discussion of Results," *Carnegie Inst. Washington Pub. 385*, pp. 64–67.

III. References to Mexican Micropaleontology

59. COLE, W. STORRS, 1927. "A Foraminiferal Fauna from the Guayabal Formation in Mexico," *Bull. Amer. Pal.*, Vol. 14, No. 51, pp. 1–46, Pls. i–v.
60. ———, 1928. "A Foraminiferal Fauna from the Chapapote Formation in Mexico," *ibid.*, Vol. 14, No. 53, pp. 1–32, Pls. i–iv.
61. ———, and RUTH GILLESPIE, 1930. "Some Small Foraminifera from the Meson Formation of Mexico," *ibid.*, Vol. 15, No. 57b, pp. 1–15, Pls. i–iv.
62. CUSHMAN, J. A., 1924. "A New Genus of Eocene Foraminifera," *Proc. U. S. Nat. Mus.*, Vol. 66, Art. 30, pp. 1–4, Pls. i–ii.
63. ———, 1925. "New Foraminifera from the Upper Eocene of Mexico," *Contrib. Cushman Lab. Foram. Research*, Vol. 1, Pt. 1, pp. 4–8, Pl. i.
64. ———, 1925. "Some New Foraminifera from the Velasco Shale of Mexico," *ibid.*, Vol. 1, Pt. 1, pp. 18–22, Pl. iii.
65. ———, 1925. "An Eocene Fauna from the Moctezuma River, Mexico," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 9, pp. 298–303, Pls. vi–viii.
66. ———, 1925. "Mexican Species of Marginulina," *Contrib. Cushman Lab. Foram. Research*, Vol. 1, Pt. 3, pp. 61–62, Pl. x (pars).
67. ———, 1925. "Notes on the Genus Tritaxilina," *ibid.*, pp. 62–65, Pl. x (pars).
68. ———, 1926. "The Genus Chilostomella and Related Genera," *ibid.*, Vol. 1, Pt. 4, pp. 73–79, Pl. xi.
69. ———, 1926. "Some Fossil Bolivinas from Mexico," *ibid.*, pp. 81–84, Pl. xii.
70. ———, 1926. "A Peculiar Frondicularia from Mexico and Trinidad," *ibid.*, pp. 88–89, Pl. xiii.
71. ———, 1926. "Some Foraminifera from the Mendez Shale of Eastern Mexico," *ibid.*, Vol. 2, Pt. 1, pp. 16–24, Pls. ii–iii.
72. ———, 1926. "The Foraminifera of the Velasco Shale of the Tampico Embayment," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10, pp. 581–612, Pls. xv–xxi.
73. ———, 1926. "Foraminifera of the Genera Siphogenerina and Pavonina," *Proc. U. S. Nat. Mus.*, Vol. 67, Art. 25, pp. 1–24, Pls. i–vi.
74. ———, 1927. "American Upper Cretaceous Species of Bolivina and Related Species," *Contrib. Cushman Lab. Foram. Research*, Vol. 2, Pt. 4, pp. 85–91, Pl. xii.
75. ———, 1927. "Foraminifera of the Genus Siphonina and Related Genera," *Proc. U. S. Nat. Mus.*, Vol. 72, Art. 20, pp. 1–15, Pls. i–iv.
76. ———, 1927. "Foraminifera of the Genus Ehrenbergina and Its Species," *ibid.*, Vol. 70, Art. 16, pp. 1–8, Pls. i–ii.
77. ———, 1927. "New and Interesting Foraminifera from Mexico and Texas," *Contrib. Cushman Lab. Foram. Research*, Vol. 3, pp. 111–17, Pls. xxii–xxiii.
78. ———, 1927. "Some Characteristic Mexican Fossil Foraminifera," *Jour. Pal.*, Vol. 1, pp. 147–72, Pls. xxiii–xxviii.
79. ———, 1932. "The Genus Vulvulina and Its Species," *Contrib. Cushman Lab. Foram. Research*, Vol. 8, pp. 75–85, Pl. x.
80. ———, 1933. "Some New Foraminiferal Genera," *ibid.*, Vol. 9, pp. 32–38, Pl. iv.
81. ———, 1934. "Notes on the Genus Spiroplectoides and Its Species," *ibid.*, Vol. 10, pp. 37–44, Pl. vi.
82. ——— and R. W. HARRIS, 1927. "Some Notes on the Genus Ceratobulimina," *ibid.*, Vol. 3, pp. 171–79, Pls. xxix–xxx.
82A. DIAZ LOZANO, A., 1917. "Diatomeas Fósiles Méxicanas," *An. Inst. Geol. México*, Tom. 1, No. 1, pp. 1–27, Pls. i–ii.
83. DORR, JAMES B., 1933. "New Data on the Correlation of the Lower Oligocene of South and Central America with that of Southern Mexico," *Jour. Pal.*, Vol. 7, pp. 432–38.
84. DOUVILLE, HENRI, 1927. "Les orbitoides de la région pétrolifère du Mexique," *C. R. Somm. Soc. Géol. France*, Fasc. 4, pp. 34–35.
85. DUMBLE, E. T., and E. R. APPLIN, 1924. "Subsurface Geology of Idolo Island, Veracruz, Mexico," *Pan-Amer. Geol.*, Vol. 41, pp. 335–46.

85A. GALLOWAY, J. J., 1928. "Notes on the Genus Polylepidina and a New Species," *Jour. Pal.*, Vol. 1, pp. 299–303, Pl. li.
86. GALLOWAY, J. J., and M. MORREY, 1931. "Late Cretaceous Foraminifera from Tabasco, Mexico," *ibid.*, Vol. 5, pp. 329–54, Pls. xxxvii–xl.
87. NUTTALL, W. L. F., 1928. "Notes on the Tertiary Foraminifera of Southern Mexico," *ibid.*, Vol. 2, pp. 372–76, Pl. i.
88. ———, 1930. "Eocene Foraminifera from Mexico," *ibid.*, Vol. 4, pp. 271–93, Pls. xxiii–xxv.
89. ———, 1932. "Lower Oligocene Foraminifera from Mexico," *ibid.*, Vol. 6, pp. 3–35, Pls. i–ix.
90. ———, 1933. "Two Species of Miogypsina from the Oligocene of Mexico," *ibid.*, Vol. 7, pp. 175–77, Pl. xxiv.
91. ———, 1934. "The Application of Micro-Palaeontology to Petroleum Geology," *Proc. World Petrol. Congress* (London, 1933), Vol. 1, pp. 270–73 (also a preprint).
92. THALMANN, HANS E., 1932. "Das Vorkommen der Gattung Miogypsina Sacco 1893 in Ost-Mexiko," *Eclog. Geol. Helvet.*, Bd. 25, pp. 282–86.
93. ———, 1934. "Lepidocyclina canellei Lemoine and R. Douvillé im Oligocän von Tabasco (Mexiko)," *Centralblatt f. Min. Geol. und Pal.*, Abt. B, No. 10, pp. 446–48.
94. VAUGHAN, T. WAYLAND, 1924. "American and European Tertiary Larger Foraminifera," *Bull. Geol. Soc. America*, Vol. 35, pp. 785–822, Pls. xxx–xxxvi.
95. ———, 1929. "Descriptions of New Species of Foraminifera of the Genus Discocyclina from the Eocene of Mexico," *Proc. U. S. Nat. Mus.*, Vol. 76, Art. 3, pp. 1–18, Pls. i–vii.
96. ———, 1929. "Actinosiphon Semmesi, a New Genus and Species of Orbitoidal Foraminifera, and Pseudorbitoides Trechmanni H. Douvillé," *Jour. Pal.*, Vol. 3, pp. 163–69, Pl. xxi.
97. ———, 1929. "Species of Orbitocyclina, a Genus of American Orbitoid Foraminifera from the Upper Cretaceous of Mexico and Louisiana," *ibid.*, Vol. 3, No. 2, pp. 170–75, Pl. xxii.
98. ———, 1922. "Studies of American Species of Foraminifera of the Genus Lepidocyclina," *Smithsonian Misc. Coll.*, Vol. 89, No. 10, pp. 1–53, Pls. i–xxxii.
99. WHITE, MAYNARD P., 1928–1929. "Some Index Foraminifera of the Tampico Embayment Area of Mexico." In 3 parts: *Jour. Pal.*, Vol. 2, pp. 177–215, Pls. xxvii; Vol. 2, pp. 280–317, Pls. xxxviii–xliii; Vol. 3, pp. 30–58, Pls. iv–v.

IV. Principal References to Mexican Macropaleontology

100. ADKINS, W. S., 1930. "New Rudistids from the Texas and Mexican Cretaceous," *Univ. Texas Bull. 3001.*
101. BARCENA, M., 1877. "Materiales para la formación de una obra de Palaeontológia Méxicana," *An. Mus. Nac.*, Vol. 1, pp. 43–46, 85–91, 195–202, 283–86.
102. BERRY, E. W., 1922. "An American Spirulirostra," *Amer. Jour. Sci.*, 5th ser., Vol. 3, pp. 327–44.
103. BOEHM, G., 1898. "Über Caprinidenkalke aus Mexico," *Zeit. der deutsch. geol. Gesell.*, Vol. 50, pp. 323–32; 11 figs.
104. BÖSE, EMIL, 1906. "La Fauna de Moluscos del Senoniano de Cardenas, San Luis Potosi," *Inst. Geol. México Bol. 24*, pp. 1–95, Pls. i–xviii.
105. ———, 1906. "Nota Preliminar sobre la fauna Pliocenica de Santa Maria Tatetla, Veracruz," *Bol. Soc. Geol. México*, Tom. 2, pp. 51–64.
106. ———, 1906. "Sobre algunas Faunas Terciarias de Mexico," *Inst. Geol. México Bol. 22*, pp. 1–96, Pls. i–xii.
107. ———, 1910. "Monografía Geológica y Paleontológica del Cerro de Muleros, Chihuahua," *ibid., Bol. 25*, pp. 1–196, Pls. i–l.
108. ———, 1913. "Sobre algunas faunas del Cretácico superior de Coahuila y regiones limitrofes," *ibid., Bol. 30*, pp. 1–56, Pls. i–viii.
109. ———, 1918. "On a New Ammonite Fauna of the Lower Turonian of Mexico," *Univ. Texas Bull. 1856*, pp. 179–234, Pls. xii–xx.
110. ———, 1923. "Algunas faunas cretácicas de Zacatecas, Durango y Guerrero," *Inst. Geol. México Bol. 42*, pp. 1–219, Pls. i–xix.
111. ———, 1927. "Cretaceous Ammonites from Texas and Northern Mexico," *Univ. Texas. Bull. 2748*, pp. 143–57, Pls. i–xviii.

112. ——— and F. TOULA, 1910. "Zur jungtertiären Fauna von Tehuantepec," *Jahrb. d. k. k. Geol. Reichsandstalt*, Bd. 60, heft 2, pp. 215–76, Pls. xii–xiii.

113. BURCKHARDT, C., 1905. "Le faune du Trias supérieur de Zacatecas (in collaboration with S. Scalia), *Inst. Geol. México Bol. 21*, pp. 1–44, Pls. i–viii.

114. ———, 1906. "Le Faune Jurassique de Mazapil," *ibid., Bol. 23*, pp. 1–216, Pls. i–xliii.

115. ———, 1912. "Faunes jurassiques et crétaciques de San Pedro del Gallo, Durango," *ibid., Bol. 29*, pp. 1–264, Pls. i–xlvi.

116. ———, 1920. "Fauna jurásica de Symon, Zac., y faunas cretácicas de Zumpango del Río, Durango," *ibid., Bol. 33*, pp. 1–137, Pls. i–xxxii.

117. ———, 1925. "Faunas del Aptiano de Nazas, Durango," *ibid., Bol. 45*, pp. 1–71, Pls. i–x.

118. ———, 1927. "Cafelópodos del jurásico medio de Oaxaca y Guerrero," *ibid., Bol. 47*, pp. 1–106, Pls. i–xxxiv.

119. CASTELLO, A. DEL, and J. G. AGUILERA, 1895. "Fauna Fósil de la Sierra de Catorce," *ibid., Bol. 1*, pp. 1–56, Pls. i–xxi.

120. COLE, W. STORRS, 1929. "A New Oligocene Brachiopod from Mexico," *Bull. Amer. Pal.*, Vol. 15, No. 57a, pp. 1–6, Pl. i.

121. COOKE, C. WYTHE, 1928. "New Vicksburg (Oligocene) Mollusks from Mexico," *U. S. Nat. Mus. Proc.*, Vol. 73, Art. 10. 11 pp., 2 pls.

122. COTTEAU, C., 1889–1890. "Note sur quelques Échinides du terrain crétace de Mexique," *Bull. Soc. géol. France*, Ser. 3, Tom. 18, pp. 292–399.

123. DIAZ LOZANO, E., 1916. "Descripción de unas plantas liásicas de Huayacocotla, Veracruz; algunas plantas de la Flora Liásica de Huauchinango, Puebla," *Inst. Geol. México Bol. 34*, pp. 1–18, Pls. i–ix.

124. ———, 1927. "Los restos fósiles de 'Elephas,' encontrados en terrenos de la hacienda de Tepextan, Hidalgo," *An. Inst. Geol. México*, Tom. 2, No. 9, pp. 201–02.

125. DICKERSON, R. E., and W. S. KEW, 1917. "The Fauna of a Medial Tertiary Formation and Associated Horizons of Northeastern Mexico," *Proc. California Acad. Sci.*, 4th ser., Vol. 7, No. 5, pp. 125–56, Pls. xvii–xxvi a.

126. DOUVILLE, H., 1896 (1897). "Étude sur les Rudistes. Distribution regionale de Hippurites," *Mém. Pal., Soc. géol. France*, 7, Mém. 6 ("Mexico," pp. 229–30, Pl. xxxvii, 15–16).

127. ———, 1900. "Sur quelques rudistes americains," *Bull. Soc. géol. France*, 3e. Ser., Tom. 28, pp. 205–21.

128. ENGERRAND, J., and F. URBINA, 1910. "Primera Nota acerca de la Fauna Miocénica de Zuluzum (Chiapas)," *Bol. Soc. Geol. México*, Tom. 6, pp. 119–40, Pls. lviii–lx.

129. ISRAELSKY, MERLE C., 1924. "Notes on Some Echinoids from the San Rafael and Tuxpam Beds of the Tampico Region, Mexico," *Proc. California Acad. Sci.*, 4th Ser., Vol. 13, No. 8, pp. 137–45, Pls. ii–iv.

130. ———, 1933. "A New Species of Echinoid from Tamaulipas, Mexico," *Trans. San Diego Soc. Nat. Hist.*, Vol. 7, No. 22.

131. LAMBERT, J., 1928. "Note sur quelques echinoides recueillis par M. Walther Staub dans le Neogéne de l'Est du Mexique," *Eclog. Geol. Helvt.*, Vol. 21.

132. MÜLLERRIED, F. K. G., 1931. "Un Reptil y Algunos Invertebrados fósiles de Rayón, Tamps.," *An. Inst. Biología*, Tom. 2, No. 2, pp. 171–78.

133. ———, 1933. "El Genero Plagioptychus en México," *ibid.*, Tom. 4, No. 1, pp. 1–14.

134. ———, 1933. "Die Bexiehungen der Pachydonten Amerikas zu denen der Alten Welt," *Geol. Rundschau*, Bd. 23a, pp. 267–71.

135. ———, 1933–34. "Estudios Paleontológicos y Estratigraficos en la Región de Tehuacan, Pue." *An. Inst. Biología*, Tom. 4, No. 2, pp. 33–46; No. 3, pp. 79–93; No. 4, pp. 309–30; Tom. 5, No. 1, pp. 55–80.

136. PALMER, R. H., 1928. "The Rudistids of Southern Mexico," *Occas. Papers California Acad. Sci.*, No. 14, pp. 1–137, Pls. i–xviii.

137. RATHBUN, MARY J., 1930. "Fossil Decapod Crustaceans from Mexico," *Proc. U. S. Nat. Mus.*, Vol. 77, Art. 8, pp. 1–10, Pls. i–vi.

138. SPRINGER, FRANK, 1922. "Crinoids from the Upper Cretaceous of Tamaulipas, Mexico," *ibid.*, Vol. 61, Art. 5, pp. 1–4, Pl. i.

139. STANTON, T. W., 1921. "A New Cretaceous Rudistid from the San Felipe Formation of Mexico," *ibid.*, Vol. 59, pp. 453–54, Pl. xcvi.

140. STEPHENSON, L. W., 1922. "Some Upper Cretaceous Shells of the Rudistid Group from Tamaulipas, Mexico," *ibid.*, Vol. 61, Art., 1, pp. 1–28, Pls. i–xv.
141. TOULA, FRANZ, 1911. "Nachträge zur jungtertiären (Pliocänen) Fauna von Tehuantepec," *Jahrb. d. k. k. Geol. Reichsenstalt*, Bd. 61, Heft 3, 4, pp. 473–86, Pl. xxix.
142. WIELAND, G. R., 1910. "Plesiosaurus mexicanus Wieland, Parergones," *Inst. Geol. México*, Tom. 4, No. 6, pp. 359–65, Pl. lii.
143. ———, 1913. "La Flora Liásica de la Mixteca Alta," *Inst. Geol. Mex. Bol. 31*, pp. 1–162, Pls. i–viii.

Editor's Note.—In addition to the references in Mr. Barker's bibliography the following general contributions to the geology of Mexico may be mentioned.

BAKER, C. L., 1928. "Panuco Oil Field," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 12, No. 4, pp. 395–441.
DE GOLYER, E. L., 1915. "The Furbero Oil Field, Mexico," *Trans. Amer. Inst. Min. Met. Eng.*, Vol. 52, pp. 268–80.
———, 1915. *Ibid., Bull. 105*, pp. 1899–1911.
———, 1915. "The Effect of Igneous Intrusions on the Accumulation of Oil in the Tampico-Túxpam Region," *Econ. Geol.*, Vol. 10, No. 7.
———, 1932. "Oil Associated with Igneous Rocks in Mexico," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 16, No. 8, pp. 799–818.
GARFIAS, V. R., 1915. "The Oil Region of Northeastern Mexico," *Econ. Geol.*, Vol. 10, pp. 195–224.
KANE, WILLIAM G., and GUY B. GIERHART, 1935. "Areal Geology of Eocene in Northeastern Mexico," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 19, No. 9, pp. 1357–88; 4 figs. Areal geology map reproduced in this *Bulletin* (April, 1936), p. 406. Article contains 5 stratigraphic sections prepared as road logs.
MUIR, JOHN M., 1934. "Limestone Reservoir Rocks in the Mexican Oil Fields," *Problems of Petroleum Geology* (Amer. Assoc. Petrol. Geol.), pp. 377–98; 6 figs. Discusses all pertinent literature.
———, 1935. "Occurrence of Natural Gas in Mexican Oil Fields, with Notes on Lake Chapala Region and Valley of Mexico," *Geology of Natural Gas* (Amer. Assoc. Petrol. Geol.), pp. 997–1010; 2 figs. Contains many references.
———, 1936. *Geology of Tampico Region, Mexico* (Amer. Assoc. Petrol. Geol.). 330+ pp., 18 halftones, 41 line drawings. In press.
———, 1934. "Sobre el hallazgo de Paquiodontos gigantescos en el cretacico de Chiapas," *ibid.*, Tom. 5, No. 1, pp. 81–82.
ORDOÑEZ, E., 1914. "The Oil Fields of Mexico," *Amer. Inst. Min. Eng. Bull. 94*, pp. 2530–35.
———, 1915. *Ibid., Trans. 50*, pp. 859–69.
———, 1916. "A Short Note on the Oil Fields of Mexico," *Soc. Cien. "Antonio Alzate" Mem. 34*, pp. 121–27.
———, 1919. "Petróleo en el sur de Tamaulipas," *ibid., Mem. y Rev.*, T. 38, Nos. 5–8, pp. 257–69.
———, 1932. "El Petróleo en México. Bosquejo Historico," *Revista Mexicana de Ingenieria y Arquitectura.*
SCHUCHERT, CHARLES, 1935. *Historical Geology of the Antillean-Caribbean Region, or the Lands Bordering the Gulf of Mexico and the Caribbean Sea.* John Wiley and Sons, Inc. (New York). 811 pp., 16 pls., 107 figs.
STANTON, T. W., 1918. "Mesozoic History of Mexico, Central America, and the West Indies," *Bull. Geol. Soc. America*, Vol. 29, pp. 601–06.
THALMANN, H. E., 1935. "Liste der Foraminiferen von der Typus-Lokalität der Miozänen Tuxpan-Stufe (Ciudad de Tuxpan, Veracruz, México)," Eclog. Geol. *Helvet.*, Vol. 28, No. 2, pp. 602–605.
———, 1935. "Stratigraphisch wertvolle Foraminiferen im Tertiär des Coatzocoalcos-Beckens (Isthmus von Tehuantepec)," *ibid.*, Vol. 28, No. 2, pp. 592–98.
———, 1935. "Die miozäne Tuxpan-Stufe im Gebiete zwischen Rio Tuxpan und Rio Tecolutla (Staat Veracruz, Ost-Mexico)," *ibid.*, Vol. 28, No. 2, pp. 543–46.
TRAGER, E. A., 1926. "The Geologic History of the Pánuco River Valley and Its Relation to the Origin and Accumulation of Oil in Mexico," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 10, No. 7, pp. 677–96; 7 figs.; 3 pls. In Spanish in *Bol Petróleo*, Vol. 22, No. 4 (October, 1926), pp. 243–60; 9 pls.

VER WIEBE, W. A., 1924. "The Stratigraphy of the Petroliferous Area of Eastern Mexico," *Amer. Jour. Sci.*, 5th Ser., Vol. 8, pp. 277–95, 385–94, 481–502.

MÜLLERRIED, F. K. G., 1930. "El Llamado Hippurites mexicana Bárcena." *An. Inst. Biolgía* (Mexico, D. F.), Tom. 1, pp. 63–70.

———, 1931. "Chiapasella, un paquiodonto extrañismo de la America." *ibid.*, Tom. 2, No. 3, pp. 243–54.

———, 1932. "Monografía del género Coralliochama." *ibid.*, Tom. 3, No. 2, pp. 169–79.

———, 1932. "El Biradiolites lombricalis d'Orb. de Ejutla, Edo. de Oaxaca.," *ibid.*, Tom. 3, No. 3, pp. 237–42.

CHART SHOWING THE RANGE OF THE MORE CHARACTERISTIC FORAMINIFERA IN THE TAMPICO EMBAYMENT, MEXICO

PREPARED BY W. L. F. NUTTALL MAY 1933

	SPECIES	LOWER MIOCENE	MIDDLE OLIGOCENE	LOWER OLIGOCENE		UPPER EOCENE			MIDDLE EOCENE	LOWER EOCENE	LOWER EOCENE & UPPERMOST CRETACEOUS		UPPER CRETACEOUS
		Tuxpam	Meson	Upper Alazan	Lower Alazan	Upper Chapapote	Lower Chapapote	Tantoyuca	Guayabal	Aragón	Chiconlepec	Velasco	Mendez
1	Cristellaria americana Cushman												
2	" americana var spinosa Cushman												
3	" vaughani Cushman												
4	Rotalia beccarii (Linne)												
5	Amphistegina lessoni d'Orbigny												
6	Orbiculina adunca (Fichtel + Moll)												
7	Heterostegina antillea Cushman												
8	Lepidocyclina canellei Lemoine + Douvillé												
9	" cf morgani Lemoine + Douvillé												
10	" gigas - undosa Cushman												
11	" crasseta Cushman												
12	Miogypsina complanata Schlumberger												
13	Bifarina vicksburgensis (Cushman)												
14	Bolivina alazanensis Cushman												
15	" caelata Cushman							r					
16	Cibicides americana Cushman												
17	Cristellaria gutticostata Gümbel												
18	" subkubingii Nutall												
19	budensis Hantken							r					
20	Epistomina elegans (d'Orbigny)												
21	Globigerina aff bulloides d'Orbigny												
22	Marginulina mexicana Cushman		c										
23	Nodosaria aff raphanistrum (Linné)												
24	Nonion hantkeni Cushman + Applin												
25	Lepidocyclina supera (Conrad)												
26	Plectofrondicularia vaughani Cushman												
27	Pseudoglandulina conica (Neugeboren)												
28	" comatula (Cushman)												
29	Eponides byramensis (Cushman)												
30	Siphonina tenuicarinata Cushman												
31	Bolivina tongi Cushman												
32	Cassidulina laevigata var. carinata Cushman												
33	Cristellaria calcar var. alazanensis Nuttall												
34	Marginulina alazanensis Nuttal												
35	Planulina alazanensis Nuttal												
36	Uvigerina spinicostata var. alazanensis Nuttall												
37	Anomalina alazanensis Nuttall												
38	Bolivina tectiformis Cushman												
39	Bulimina sculptilis Cushman			c									
40	" inflata Seguenza												
41	Cancris sagra (d'Orbigny)												
42	Cassidulina subglobosa Brady												

r = rare c = common

r = rare c = common

	SPECIES	LOWER MIOCENE	MIDDLE OLIGOCENE	LOWER OLIGOCENE		UPPER EOCENE			MIDDLE EOCENE	LOWER EOCENE	LOWER EOCENE & UPPERMOST CRETACEOUS		UPPER CRETACEOUS
		Tuxpam	Meson	Upper Alazan	Lower Alazan	Upper Chapapote	Lower Chapapote	Tantoyuca	Guayabal	Aragón	Chicontepec	Velasco	Méndez
43	Clavulina alazanensis Nuttall												
44	Cristellaria formosa Cushman												
45	" limbosa (Reuss)												
46	Dentalina cocoaensis (Cushman)												
47	" multilineata Bornemann												
48	" semilaevis Hantken												
49	Discorbis araucana (d'Orbigny)												
50	Ehrenbergina semmesi Cushman												
51	Flabellina semiornata Nuttall												
52	Frondicularia tenuissima Hantken												
53	Gaudryina asiphonia (Andreae)												
54	" cylindrica Nuttall												
55	Globigerina concinna Reuss												
56	Guttulina irregularis (d'Orbigny)												
57	Marginulina pseudohirsuta Nuttall												
58	Nodosaria acuminata Hantken												
59	" spinicosta d'Orbigny			r									
60	Pavonina mexicana Cushman												
61	Planulina mexicana Cushman			c									
62	Rectobolivina mexicana Cushman												
63	Sigmoilina tenuis (Czjzek)												
64	Textularia mississippiensis var. alazanensis Nuttall												
65	Uvigerina alazanensis Nuttall			c									
66	" tenuistriata Reuss			r									
67	" auberiana d'Orbigny												
68	Vaginulina alazanensis Nuttall												
69	Verneuilina mexicana Nuttall												
70	Virgulina nodosa Stewart												
71	Bulimina ovata d'Orbigny												
72	" pupoides d'Orbigny												
73	Chilostomella ovoidea Reuss							r					
74	Cibicides trinitatensis (Nuttall)												
75	Cristellaria kemperi Hanna							c					
76	" convergens Bornemann												
77	" aff. latifrons Brady							r					
78	" sublituus Nuttall							r					
79	" helena Karrer												
80	Eponides affinis (Czjzek)							r					
81	" umbonata (Reuss)												
82	Frondicularia alazanensis Nuttall												
83	Gaudryina jacksonensis Cushman			c				r					
84	Marginulina subbullata Hantken							r					
85	Pullenia quinqueloba Reuss												
86	Uvigerina aff. gardnerae Cushman + Applin												
87	" mexicana Nuttall					r							
88	Anomalina mecatepecensis Nuttall												
89	Ceratobulimina alazanensis Cushman												
90	Cibicides urigeriana (d'Orbigny)												

r = rare c = common

	SPECIES	LOWER MIOCENE	MIDDLE OLIGOCENE	LOWER OLIGOCENE		UPPER EOCENE			MIDDLE EOCENE	LOWER EOCENE	LOWER EOCENE & UPPERMOST CRETACEOUS		UPPER CRETACEOUS
		Tuxpam	Meson	Upper Alazan	Lower Alazan	Upper Chapapote	Lower Chapapote	Tantoyuca	Guayabal	Aragon	Chicontepec	Velasco	Mendez
91	Cibicides akneriana (d'Orbigny)												
92	Cristellaria italica (De france)												
93	Gaudryina colei Nuttall												
94	Globorotalia menardii (d'Orbigny)												
95	" palmarealensis Nuttall												
96	Gyroidina broeckhiana (Karrer)												
97	Lepidocyclina asterodisca Nuttall												
98	" aff. giraudi R Douville												
99	" mantelli (Morton)												
100	Nonion pompilioides (Fichtel + Moll)												
101	Rotalia vicksburgensis Cushman												
102	Sphaeroidina bulloides d'Orbigny												
103	Spiroculina aff. depressa d'Orbigny												
104	Textularia dentimarginata Nuttall												
105	Chilostomella oviformis (Sherborn + Chapman)												
106	Planulina wuellerstorfi (Schwager)												
107	Cibicides mexicana Nuttall												
108	Cristellaria subpapillosa Nuttall												
109	Dentalina adolphina d'Orbigny												
110	Ellipsoglandulina labiata (Schwager)												
111	Gaudryina bradyi Cushman												
112	Polymorphina elegantissima Parker + Jones												
113	Pullenia sphaeroides d'Orbigny												
114	Pulvinulinella culter var. mexicana Cole												
115	Rotalia mexicana var. mecatepecensis												
116	Vulvulina capreolus var. spinosa Cushman												
117	Cibicides perlucida Nuttall												
118	Clavulina triangularis Nuttall												
119	Ellipsoglandulina multicostata (Galloway + Morrey)												
120	Lepidocyclina favosa Cushman												
121	" pseudomarginata Cushman												
122	Nodosarella salmojraghii Martinotti												
123	Cibicides tuxpamensis Cole								r				
124	" cushmani Nuttall												
125	Cristellaria crepidula (Fichtel + Moll)												
126	Nodosarella subnodosa (Guppy)							r					
127	Gyroidina girardana (Reuss)												
128	Nodosaria boffaloraе Martinotti												
129	Pleurostomella alternans Schwager												
130	" alazanensis Chusman												
131	Vaginulina elegans var. mexicana Nuttall							r					
132	Anomalina grosserugosa Gümbel												
133	Cibicides refulgens (Monfort)							r					
134	Cibicides pygmaea (Hantken)												
135	Rotaliatina mexicana Cushman					c							
136	Bulimina aff. jacksonensis Cushman												
137	" tuxpamensis Cole												
138	Cassidulina cushmani Stewart												

r = rare c = common

SPECIES	LOWER MIOCENE	MIDDLE OLIGOCENE	LOWER OLIGOCENE		UPPER EOCENE			MIDDLE EOCENE	LOWER EOCENE	LOWER EOCENE & UPPERMOST CRETACEOUS		UPPER CRETACEOUS
	Tuxpam	Meson	Upper Alazan	Lower Alazan	Upper Chapapote	Lower Chapapote	Tantoyuca	Guayabal	Aragón	Chicontepec	Velasco	Méndez
139 Tritaxilina mexicana Cushman					c			r	r			
140 Anomalina dorri Cole												
141 Cassidulina globosa Hantken					r							
142 Cibicides grimsdalei Nuttall												
143 Trochammina irregularis White												
144 Textularia eocaena Gümbel, Cole												
145 Hantkenina alabamensis Cushman												
146 Cristellaria mexicana var. nov.												
147 Hantkenina brevispina Cushman												
148 Pulvinulina cerroazulensis (Cole)												
149 Anomalina umbonata Cushman												
150 Bulimina semicostata Nuttall												
151 Cibicides subspirata Nuttall												
152 Eponides trümpyi Nuttall										r		
153 Globigerina inflata d'Orbigny												
154 Nonion micrus Cole												
155 Asterocyclina aff asterodiscus (Guppy)												
156 Bulimina jacksonensis Cushman var							c					
157 Lepidocyclina cf. marginata (Michelotti)												
158 " aff. ocaiana Cushman												
159 Cristellaria mexicana Cushman								c				
160 Eponides guayabalensis (Cushman)												
161 " mexicana Cushman												
162 Lingulina mexicana Cole												
163 Nodosaria mexicana Cushman								c				
164 Operculina wilcoxi (Heilprin) & vars.							c					
165 Amphistegina mexicana Cole												
166 Ceratobulimina eximia (Rzehak)												
167 Cibicides sassei Cole												
168 Discocyclina cushmani Vaughan												
169 " perpusilla "												
170 Frondicularia interrupta Karrer												
171 Globigerina mexicana Cushman												
172 Lepidocyclina proteiformis Vaughan												
173 Operculina cushmani Cole												
174 Planorbulina guayabalensis Nuttall												
175 Textularia zapotensis Cole												
176 Globigerina topilensis Cushman												
177 Globorotalia spinulosa Cushman												
178 " crassata Cushman												
179 Hantkenina longispina Cushman												
180 Heterostomella dalmatina (Liebus)												
181 Haplophragmoides acutidorsatum (Hantken)												
182 Cristellaria asperuliformis Nuttall												
183 Globigerina pseudobulloides Plummer												
184 " aff orbiformis Cole												
185 Glomospira charoides (Jones + Parker)												
186 Hantkenina mexicana var aragonensis Nuttall												

r = rare c = common

	SPECIES	LOWER MIOCENE	MIDDLE OLIGOCENE	LOWER OLIGOCENE		UPPER EOCENE			MIDDLE EOCENE	LOWER EOCENE	LOWER EOCENE & UPPERMOST CRETACEOUS		UPPER CRETACEOUS
		Tuxpam	Meson	Upper Alazan	Lower Alazan	Upper Chapapote	Lower Chapapote	Tantoyuca	Guayabal	Aragon	Chiconlepec	Velesco	Mendez
187	Hasterigerinella eocaenica var. aragonensis Nuttall												
188	Textularia aragonensis Nuttall												
189	" agglutinans d'Orbigny												
190	Verneuilina triquetra (Munster)												
191	Vulvulina pectinata var. mexicana Nuttall												
192	Anomalina dorri var aragonensis Nuttall												
193	Bulimina elegans d'Orbigny										c		
194	Cornuspira polygyra Reuss												
195	Globigerina cretacea d'Orbigny											c	
196	Globorotalia aragonensis Nuttall									c	r		
197	Loxostomum applinae (Plummer)												
198	Discocyclina stephensoni Vaughan												
199	" weaveri Vaughan												
200	Gaudryina sp. nov.												
201	Hantkenina sp. nov.												
202	Rectobolivina sp. nov.												
203	Gumbelina globulosa (Ehrenberg)										c		
204	Globorotalia velascoensis Cushman										c		
205	Anomalina velascoensis Cushman												
206	Flabellina reticulata Reuss										r		
207	" rugosa d'Orbigny												
208	Rotalia beccariiformis White												
209	Textularia velascoensis Cushman												
210	Gaudryina laevigata var. piramidata Cushman										r		
211	Globorotalia membranacea (Ehrenberg)												
212	Gyroidina naranjoensis White												
213	Nodosinella velascoensis Cushman										r		
214	Rzehakina epigona (Rzehak)												
215	Bolivina decorata Jones												
216	Cornuspira cretacea Reuss												
217	Flabellina interpunctata von der March										r		
218	Gaudryina retusa Cushman												
219	" laevigata Franke												
220	Gyroidina florealis White												
221	Planulina dayi White												
222	Ramulina globulifera Brady												
223	Rotalia velascoensis (Cushman)												
224	Flabellina delicatissima Plummer												
225	Karreria fallax Rzehak												
226	Spiroplectoides clotho (Grzybowski)												
227	Bolivina incrassata Reuss												
228	Globotruncana arca Cushman												c
229	" rosetta (Carsey)												c
230	Pseudotextularia varians Rzehak												
231	varians var textulariformis White												

r = rare c = common

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 20, NO. 4 (APRIL, 1936), PP. 457-466

GEOLOGIC ROAD LOG OF PAN-AMERICAN HIGHWAY, LAREDO TO MEXICO CITY[1]

SAN ANTONIO GEOLOGICAL SOCIETY[2]
San Antonio, Texas

The Laredo Chamber of Commerce in the Hamilton Hotel, Laredo, will arrange for your crossing the border. At this office obtain preliminary passport and car-bonding papers. This office will also change your money and answer any questions.

Drive to the bridge where no stop is necessary at the American Customs at north end of bridge, unless you have valuable cameras, jewelry, or furs which you may register so there will be no question of duties when you return.

Pay toll fare in middle of bridge: 15 cents per car, 5 cents for each person.

Stop at Mexican Customs office on south end of bridge for customs, health and immigration inspections and to complete your papers.

Laredo, Texas, has a population of 35,000. It is the center of Laredo oil-producing district, has two oil refineries and is the principal inland port to Mexico.

Miles from Nuevo Laredo	*Kilometers*	(Notice kilometer posts along highway, giving *distance from Mexico City.*)
0	1229.2	Main Plaza in Nuevo Laredo. Follow paved street south. Cook Mountain on surface. Nuevo Laredo—population 15,000—lard, soap, furniture factories and flour mill. Note: first 43 miles longest straight paved highway tangent in the world.
	1221.8	Arroyo Coyote.

[1] This log and accompanying map were used on the 7th annual field trip of the San Antonio Geological Society from Laredo to Mexico City in connection with the mid-year meeting of the Association at Mexico City, October 16–19, 1935. Subsequent road construction and elimination of detours and ferries will change the mileage slightly.

[2] Officers in 1935: president, Joseph M. Dawson; vice-president, Philip S. Schoeneck; secretary-treasurer, Adolph Dovre; members of executive committee, T. J. Galbraith and Ira O. Brown. Log prepared by J. L. Tatum and Joseph M. Dawson.

Miles	*Kilometers*	
13	1207.6	San Antonio Customs Post. (Stop for inspection.)
	1206.6	Cook Mountain-Mount Selman (undivided) contact.
	1195.5	Mount Selman-Carrizo contact. The Carrizo can be separated in the field on its lithology from the balance of the Mount Selman.
	1194.	Palafox sandstone at base of upper Mount Selman.
	1192.	Carrizo-Wilcox contact.
	1187.4	Wilcox-Midway contact (Puerto Colorado ridge).
	1185.2	Midway-Navarro contact.
	1184.4	Tamaulipas-Nuevo Leon state boundary. Note shape of long, narrow strip of the state of Tamaulipas extending along the Texas border. This part of Tamaulipas was taken away from the State of Nuevo Leon at the time of the Texas revolution and the Government decided to separate Nuevo Leon from Texas because the citizens of Nuevo Leon sympathized with Texas in its revolution.
	1180.3	Navarro-Taylor contact. The Taylor formation at this point has been brought up over the Salado arch. Taylor outcrop along road is 9.5 km. wide.
	1170.8	Taylor-Navarro contact.
	1161.8	Navarro-Taylor contact. Contact at this point is covered by Quaternary gravel. About 1 km. north and south of road the contact can be seen. Gravel is of Tamaulipas limestone.
48	1154.	Rio Salado. About 1,000 km. northwest of this point the Rio Salado has been dammed at the town of Don Martin. Water from this lake is used to irrigate an extremely large area of extensive agriculture. Extremely good fishing in lake. Road to Don Martin turns right just beyond and across the Rio Salado. Note the purple sage.
67	1124.	Town of Vallecillo. Outcrop of San Felipe limestone (lower part of Upper Cretaceous, ap-

GEOLOGIC MAP

TO ACCOMPANY ROAD LOG

LAREDO TO MEXICO CITY

SAN ANTONIO GEOLOGICAL SOCIETY

SEVENTH ANNUAL MEETING - MEXICO CITY

OCTOBER 16-19, 1935

GEOLOGIC MAP

TO ACCOMPANY ROAD LOG

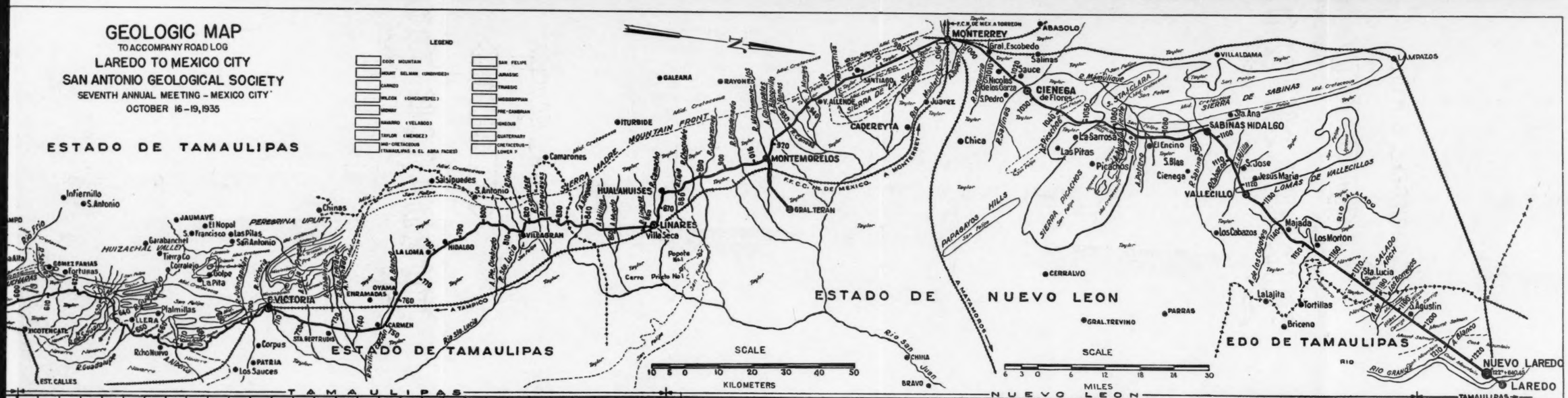
LAREDO TO MEXICO CITY

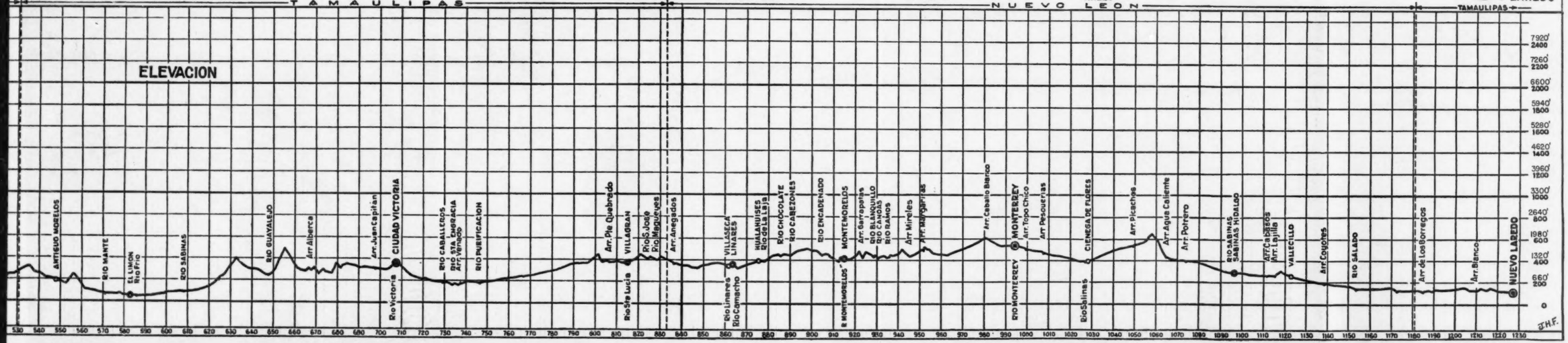
SAN ANTONIO GEOLOGICAL SOCIETY

SEVENTH ANNUAL MEETING - MEXICO CITY

OCTOBER 16-19, 1935

ESTADO DE TAMAULIPAS





Miles *Kilometers*

named after the Count of Monterrey, a duchy in Spain. It was largely settled by Portuguese Jews. It is the principal manufacturing city in the Republic, and is called the economic capital of northern Mexico. Here is located the large American Smelting and Refining Company and American Metal Company smelters; steel mills; cement plants; the large Guactemoc brewery—free beer from 12 to 2 P.M. in park. Pancho Villa stabled his horses in the lobby of the Ancira Hotel. The notable points of interest are Chipinque, a delightful inn over 5,000 feet in elevation, about 8 miles from the city, with good food and a marvelous panorama. Huasteca Canyon, where vertical Tamasopa limestone and overturned folds are exposed—about 10 miles from town. The Bishop's palace (Obispado), a monastery overlooking the city. It was captured by Zachary Taylor in the Mexican War of 1846 and caused the capitulation of Monterrey. The Terpsicore dancing garden—the most beautiful place to dance you have ever seen. Horesetail Falls (Cola de Caballo), about 20 miles in beautiful canyon. Falls are mist-like and ethereal in appearance. Dancing on roof of Casino Club every Sunday night. Guest cards are necessary; it is very elaborate and cool. Band concerts and promenade every Wednesday and Sunday night on Main Plaza.

(Side trip)—(Saltillo is 56 miles southwest over paved road. Established in 1535 as fort and mission. Elevation, 5,200 feet. Capital of the State of Coahuila and originally the Capital of Texas. Center of blanket-making industry.) Road from Monterrey to Villa Allende goes east on street one block south of cathedral. Keep on pavement, pass new country club on left. Road follows a valley between the Sierra Madre mountain front on the west and the outlying Sierra de la Silla on the left. Valley floor of Taylor (Mendez) shales. San Felipe and Tamaulipas limestone outcropping in the mountains.

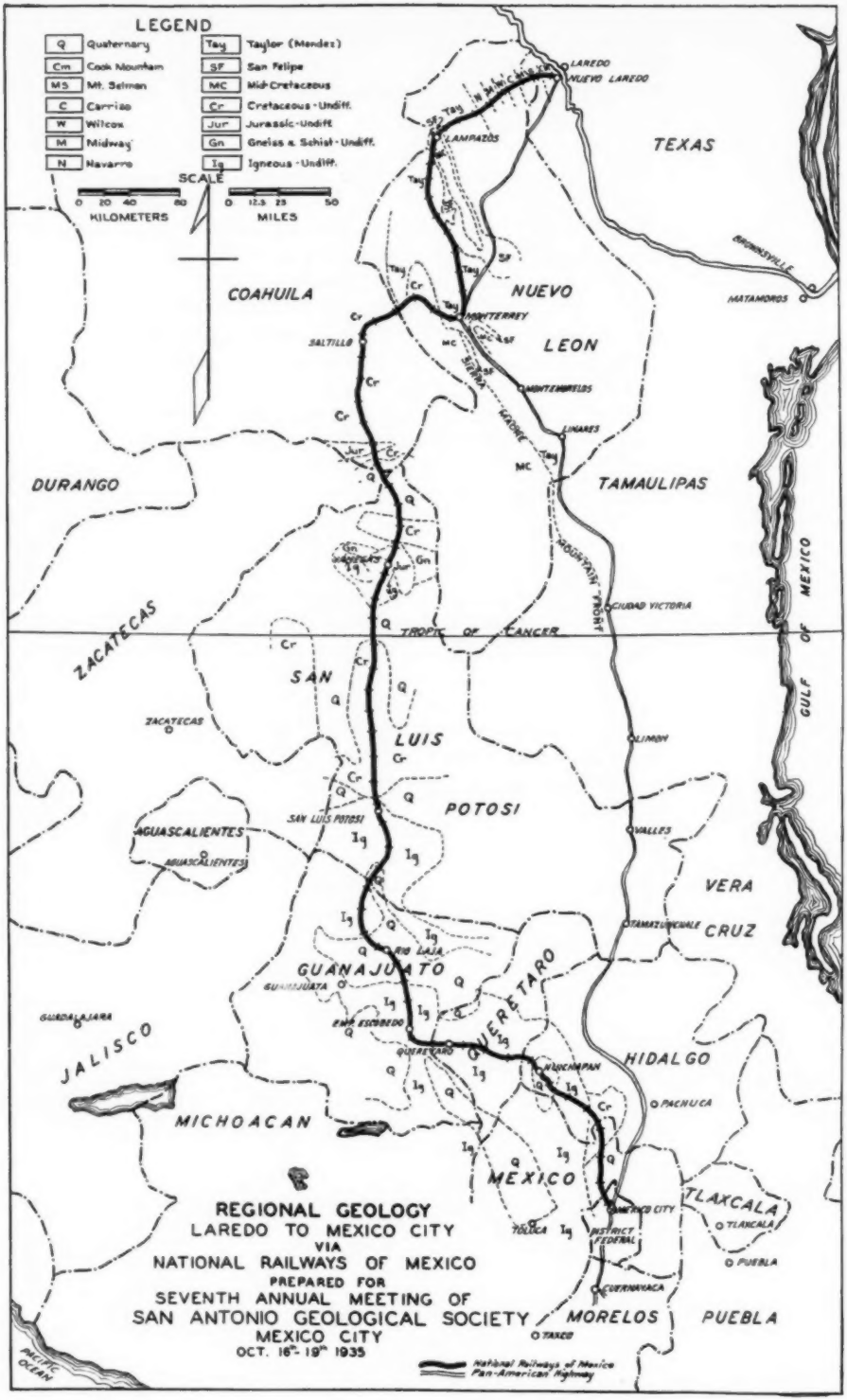
Miles	*Kilometers*	
197	914	Town of Montemorelas. Turn right when you enter town. Established in 1630 by Sergeant-Major Carlos Cantu, famous Indian fighter. He pacified, for the Spaniards, a large part of the Indians of northern Mexico and was granted about 5,000,000 acres of land for his services. He had one Spanish and three Indian wives and worked for a living. The best oranges in North America are grown here. Gasoline available.
231	864	Town of Linares. Half-way along east edge of town, turn right for 8 blocks, then left and south again. In southwest corner of the Plaza is Hotel Ramal. Good French cooking and refreshments. Northeast of Linares, hills of outcropping San Felipe sandstone which are the northwestern extension of the Sierra de San Carlos. Two wildcat wells have been drilled northeast of Linares, being Norman-Mex, Cerro Prieto No. 1, abandoned at 640 feet, and the Agwi Popote, No. 1, completed at 3,001 feet as a dry hole, penetrating Middle Cretaceous limestone at 1,901 feet. Goat center of North America. An old Texas custom—no paving through town. Gasoline station and garage.
	832.5	Nuevo Leon-Tamaulipas state boundary.
264	815.	Villagran. Small outcrop San Felipe limestone east of town. Cafe Villagran for refreshing drinks. Clean and attractive. Coca Cola for sale. Carlos Aguayo, proprietor.
	758.	Cross railroad tracks Monterrey-Tampico.
329	708	Ciudad Victoria, capital of State of Tamaulipas. Less than 10 kilometers west of Victoria is the Peragrina uplift with Jurassic, Triassic, Mississippian, and pre-Cambrian exposed. Well worth seeing. Southwest of Victoria is the Huizachal Valley on the Jaumave road where Jurassic, Triassic, and Pre-Cambrian are exposed. There are two fair hotels here: Hotel Palacios and Victoria. Good Ford garage and gasoline station. To leave Victoria return to highway by which you entered and turn south again.

Miles	*Kilometers*	
	700–620	Southeast of Victoria the road swings away from the mountain front to outlying foot hills of Tamaulipas and San Felipe limestone and mesas of igneous rock.
349	676	Tropic of Cancer. In the tropics now.
	674	Mendez (Taylor)-Velasco contact. Watch for tigers, mountain lion, and deer along here.
	644	Velasco-Mendez (Taylor) contact. Notice view from mesas south toward El Mante sugar-cane country.
	620–557	Road in general parallels the mountain front from Limon at Kilometer 582 to Canton Pass; road gradually approaches the mountain front. The mountain front as expressed in the Sierras Del Abra and Tanchipa and Sierra de Cuchares is faulted and overturned. Note that the San Felipe limestone is not present along the mountain front. Both the Tamaulipas and El Abra facies of Middle Cretaceous are exposed in these mountains.
403	595	Town of Limon. Gasoline stations. Start 8-mile detour to left on gravel road to Villa Juarez (El Mante) on Tampico road. Follow signs.
411	585	El Mante. 30-room hotel and fair meals (Gran Hotel). Modern sugar mill. Center of large irrigated district. Possible to spend night here and continue to Mexico City next day. Suggest going ahead if it is not too late. Get an early start if you spend the night here. Follow signs out of El Mante over new right-of-way.
	557–554	Canton Pass. Road enters the Sierra Madre mountain front by means of the Canton Pass. The contacts are the Tamaulipas and San Felipe limestones, and the San Felipe limestone and Taylor (Mendez) shales are well exposed on the eastern side of the synclinal valley of Antiguo Morelos.
	548	Town of Antiguo Morelos.
	498	Mendez (Taylor)-San Felipe contact.
	482	San Felipe-Mendez (Taylor) contact.
	478	Cross Tampico-San Luis Potosi railroad.

Miles	*Kilometers*	
476	477	Town of Valles. Good place to eat and spend the night and make the city next day. Two hotels —Casino and new hotel. Starting here you approach the mountains. Watch for parrots and wild game.
	475	Mendez (Taylor)-San Felipe contact.
	464	El Banito, Sulphur Springs—good tourist cottages and food. Try a swim. Good place to spend the night.
	463	Mendez (Taylor)-San Felipe contact.
489	458	Pujal—Ferry across Tampoan River. Stop at top of river bank until ferry is moored on your side. Two cars at a time, about 5 minutes to cross. Paving ends. Good gravel here to Tamazunchale.
	456	San Felipe-Mendez contact.
	454	Mendez-San Felipe contact.
	453	San Felipe-Tamaulipas contact.
	448	Tamaulipas-San Felipe contact.
	447	San Felipe-Mendez contact.
497	444	Side road to left up sharp hill. Three miles to interesting Indian village of Tancanhuiz. Flowers and market. Living customs same as 2,000 years ago.
	443	Mendez-San Felipe contact.
	442	San Felipe-Tamaulipas contact.
	436	Tamaulipas-San Felipe contact.
	435	San Felipe-Mendez contact.
	426–374	Road traverses Mendez shales. The Chicontepec formation (probably Wilcox equivalent of the Tampico Embayment) outcrops east of the road.
518	410	Huichihueyan. Magnificent scenery. Say hello to Sam Brown in small store on left side of highway.
530	390	Gulf Camp where good food may be obtained and shelter is provided. Anyone who has cots and bedding is invited to spend the night. Swede Neilson and Stubby Allen invite everyone to stop by for a visit and refreshments. Axtla River. Ferry crossing.

Miles	*Kilometers*	
	372	Mendez-San Felipe contact.
	371	Moctezuma River. Ferry crossing.
541	370	Village of Tamazunchale, San Felipe-Tamaulipas contact. Spend the night here before driving to the city next day. Several hotels and tourist camps. Hotel Vega. The D. Z. Courts or Gandy Court. Better eat at Royal Cafe. Saturday night there's a big time in the old town on and around the Plaza. Indian games and music. From Tamazunchale south there are 100 miles of solid mountain driving with scenery beyond description. For 10 miles you follow up the left bank of the Moctezuma River and then climb abruptly to the top of a high ridge which leads to the Central Plateau district of Mexico. Note the road profile on the accompanying map. You are first on one side and then on the other of the towering ridge where you can look far below to the rivers which dwindle to blue threads.
	365	Tamaulipas-Jurassic contact.
561	356	Taman village. The big climb starts here—take it easy. Gravelling crews at frequent intervals all the way to Chapulhuacan.
571	340	Chapulhuacan village. From this point the highway gets better and better.
604	272	Jacala. First seen from 2,000 feet above. Then you sweep down to enter one of the most beautiful and typical villages along the highway. Look up Tom Simpson, a mining engineer, for good food and refreshments and information. After leaving Jacala you drive over a highway smooth as glass cut from limestone. The road rises swiftly to 7,800 feet and in this area you have some of the most magnificent scenery.
624	242	Notice the great cliffs which you are skirting. These are Lower Cretaceous intruded by Tertiary or later intrusives.
646	205	Town of Zimapan at your right.
	190	Detour across old bridge spanning Tula River. Steep grades, but short ones, on both sides.

Miles	*Kilometers*	
668	170	Ixmiquilpan at your left. Worth a visit if you have the time. This is the capital of the Otomi Indian tribes. Quaternary on the surface.
	118	Actopan. Note Cretaceous-igneous contact.
706	98	High Point—8,100 feet on highway.
715	84	Colonia. Junction of Pan-American with Pachuca highway. Pachuca 8 miles toward left. Great silver mining center. Supplies 1/8 of the silver of the world. Should be visited.
	66	Igneous-Quaternary contact. Note igneous ridges in distance toward west and southeast. Snow-capped volcanoes, Popocateptl and Ixtacihuatl, 17,992 feet and 17,444 feet, respectively.
764	6	Shrine of Guadalupe on small hill at right. (Igneous.) Highway crosses street car track. Turn left. Keep going straight ahead until you reach cathedral on your left. Turn right on Avenida Cinco de Mayo, which leads to center of Mexico City and hotel district.
767	0	Turn left at end of Avenida Cinco de Mayo, then right on Avenida Juarez, past Juarez Park on your right. Hotel Regis, meeting headquarters, in next block on right.



Map of regional geology along National Railway of Mexico, from Laredo to Mexico City.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 20, NO. 4 (APRIL, 1936), PP. 467-477, 1 FIG.

GEOLOGIC ROAD LOG IN TAMAULIPAS AND NUEVO LEON, MEXICO[1]

SAN ANTONIO GEOLOGICAL SOCIETY[2]
San Antonio, Texas

NUEVO LAREDO—VALLECILLO—AGUALEGUAS GRAL. TREVINO—SAN PEDRO—RANCHERIAS CAMP

Miles	
0.0	Main Plaza, Nuevo Laredo
0.4	Railroad crossing
2.7	Flying field
4.0	Arroyo Coyote
6.2	Orange-red sandstone (Cook Mountain)
9.4	Radio Station (XENT)
13.2	STOP—Federal Inspection
16.2	Cook Mountain-Mount Selman contact
19.2	Sandstone ride (Ebano)
20.8	Sandstone ridge (Columbia)
21.3	La Como Ranch (top of Palafox ridge)
21.6	Km. 1205 (Palafox sandstone)
22.0	Stone house
22.3	Mount Selman-Carrizo contact
22.6	Massive castellated red-weathering Carrizo sandstone
23.4	Piedra Ranch
23.6	Carrizo-Wilcox contact
24.0	Sandstone ridge
25.6	Argillaceous sandstone ridge
25.8	Wilcox-Midway contact (dip 12°) (Puerto Colorado gate)
27.8	Midway-Cretaceous contact (state line)
33.8	Las Vallas tank
36.8	Guerrero road intersection
45.1	La Gloria gas station (Cameron road intersection)
46.1	End of 45 miles straight road (world's longest paved tangent)
46.3	Rio Salado: 1 hour
64.1	Lead and zinc mines at right (San Felipe limestone exposed)

[1] This log and accompanying map were used on the 6th annual field trip of the San Antonio Geological Society, November 4 and 5, 1934. Subsequent changes in the road have probably changed slightly the mileage shown in this log.

[2] Officers in 1934: president, T. J. Galbraith; vice-president, A. E. Getzendaner; secretary-treasurer, William H. Spice, Jr.; members of executive committee, Stuart Mossom and Julian Myers. Chairman, Mexico field trip committee, William G. Kane.

Miles	
64.4	Vallecillo. Turn left at Casa Blanca store. 1 hour, 35 minutes
64.7	Road fork, take left fork
65.1	Keep to left
67.0	Fence corner on right
67.9	Road fork, take right fork
69.0	Down off gravel hill
69.1	Road comes in from left
69.4	Ranch
70.9	Exposure of Papagallos shale (Taylor)
73.3	Arroyo
73.7	Road from ranch at right
74.0	Keep to left
76.4	Road from right
77.5	Road fork, take right fork
78.1	Good road from right
78.3	Road from left
78.4	Mud-hole. Arroyo Sabinas
78.6	San Carlos Ranch. 2 hours
83.3	Road fork, take right fork, straight road goes to Palo Alto
83.7	Cross-roads to Sabinas, Palo Alto, and Parras
84.1	New field on left
84.4	Sabinas road comes in from right
84.7	Alamo Post office
84.8	Rio Alamo. Cross river
85.0	Alamo school house
85.1	Road fork, take right fork
85.7	Keep to right
85.9	Detour to right, back on road 87.0
86.7	Cross road
88.4	Ranch La Perla, white well
89.0	Road from left
89.8	Tinajeros Ranch
89.9	Right fork
90.3	Enter brecha
91.3	Old road from right
92.6	Ranch
92.8	Turn left around corner
92.9	Road fork, take left fork
93.4	Old road from right
94.2	Old road from left
98.4	Old road from left along brecha

Miles	
99.7	Good road from left
104.5	Road fork, take right fork
105.3	Graveyard on left
105.5	Turn left down street
105.7	Gas station, Agualeguas
105.8	Turn right 2 blocks (pink building)
106.0	Plaza, Agualeguas, at right. 3 hours, 30 minutes
106.1	Gas station
106.2	Cross Rio Agualeguas
106.4	Keep straight ahead
106.8	Take left road, good road to right
107.1	Take right fork, good road to left
107.3	Black shale with maroon concretions
107.6	Sandstone
108.6	Old road to right
109.1	Road from left
109.4	Down, off platy sandstone
110.1	Left over sandstone
110.8	Platy sandstone in arroyo
111.0	Turtle-back concretions
111.5	Road forks all same
111.7	White ranch house on left
112.0	Road from right
112.9	Good road from left
113.2	Right fork
113.5	Cross bridge and turn left
113.7	Plaza, Gral. Trevino
114.0	Turn left and then right
116.3	Good road to left to San Javier
120.9	Good road from left from San Javier
121.1	Good road from left
127.4	Quirogas Ranch. Custom inspection
128.4	Wilcox shales with calcareous concretions
129.4	Platy calcareous sandstone of the Wilcox
129.9	Arroyo San Domingo
130.5	Red sandstone scarp of Carrizo sandstone
132.3	High sandstone ridge correlated with massive sandstones at bottom of upper Mount Selman as described at Palafox and Hidalgo on Rio Grande north of Laredo
132.8	Red shale, Mount Selman
133.5	Ruined house on left and cross road

Miles	
134.0	Road to right to Mount Selman-Cook Mountain contact
134.4	Cross road
134.7	Yellow sandstone at gate. Ranch on left
135.0	Ranch on left
136.0	Road to right to Borregas Ranch
136.1	Silicified fossil bed
136.2	Road from Borregas Ranch
136.4	Fossil ledge
136.5	*Turritella* bed in Cook Mountain underlain by concretionary and fossiliferous sandstone beds of the Cook Mountain
136.6	Fossils and conglomerate with black chert pebbles (Cook Mountain)
136.8	Turn right along conglomerate ridge
137.6	Two cross roads, take left fork
138.4	Road from right
139.8	Munoz-Martinez well, turn right around well
140.0	Pipe line
141.3	Meet United Gas Company main line to Monterrey. Turn left
141.5	Turn right on La Presa pipe line
143.1	Fossil sandstone on northwest side of La Presa structure
145.5	West line of La Presa property
146.5	La Presa No. 2
146.8	La Presa No. 1, turn left
147.2	Meet road from La Presa No. 2
148.2	Gate, east line of La Presa property
148.5	Dip slope, top of Cook Mountain
148.9	Turn left around fence corner
149.0	Turn right, then straight ahead
149.2	Cross Mier-Aldamas road
149.3	Mier. Oyster sandstone (Lower Yegua)
150.0	Road from Chapote and Lopez
150.3	Road fork, take right fork
150.9	Ash bed and silicified fossils
151.4	Red clay under "97" sandstone
152.0	Road fork, take left fork
152.2	Three roads, take middle fork
152.6	Tank. Near top of Yegua
152.8	Road from right, oysters and magnetite sandstone
153.6	Oyster bed
154.1	Heavy oyster bed (Los Guerros oyster)

Miles	
154.8	Oyster Hill
156.0	Road from left
156.2	Road from right
156.3	Road fork, take right fork
156.6	Los Guerros Ranch. Mier-San Pedro road, turn right along pipe line
157.1	Detour to right
159.9	Road from Rancherias and Camargo comes in from right
160.3	San Pedro de Roma (Roma, Texas, across bridge. 7 hours, 20 minutes). Turn back on same road
160.7	Road fork, take left fork (same as at 160.9)
160.8	Arroyo San Pedro, cross arroyo, then turn left and follow telephone line
170.6	Rancherias. Turn right, leave telephone line
173.3	Rancherias Camp of Ohio-Mexico Oil Corporation, S. A.

RANCHERIAS CAMP—CAMARGO—STA. GERTRUDIS—SINCLAIR RIO BRAVO NO. 5—MONTERREY

0.0	Rancherias Camp of Ohio-Mexico Oil Corporation, S. A.
0.7	Cattle guard, keep to left
1.0	Rancherias well No. 2
1.1	Out gate to south and turn to left
1.6	Oyster sandstone, No. "19" sandstone (Jackson)
1.9	Fossiliferous sandstone, No. "58" sandstone
2.4	Fossiliferous sandstone, "Villa Nuevo sandstone" (Jackson)
2.8	Road from left from ranch
2.9	Meet main road from San Pedro to Camargo
3.5	Along telephone line at left to Mission on Rio San Juan, Cross river on ferry to Camargo
3.6	Gas station at Camargo, turn right at next corner (30 minutes)
3.7	Calle Libertad, 2 blocks south of market. Take left fork of road south of telephone line and keep telephone line on left
4.5	Road leaves telephone line (pole with rag)
6.4	Cross telephone line running N. 32 W.
6.8	Railroad crossing. Cross track and continue straight ahead into brush
7.2	Old shack and fence corner on left
8.2	Road fork, take right fork
8.5	Cross road
8.7	Road comes in from left

Miles	
9.4	Brush fence at left
9.6	Cross brecha
10.2	Edge of gravel, black chert pebbles
11.6	Red brown clay
14.0	Yellow sandstone and cannon ball concretions
14.5	Ranch Garza. Road fork, take right fork
15.2	Ranch
16.3	Ranch at left
17.5	Road comes in from left. Same road as left fork at Ranch Garza
17.6	Big arroyo
18.2	Turn left through Sta. Gertrudis
18.3	Sta. Gertrudis cross road to Valadeces, white house on left (1 hour, 40 minutes)
18.4	Good road to left
18.6	Good road from right
18.7	Good road from right
19.7	Sandstone, probably Vicksburg (Warner) black chert pebble gravel
20.3	Lagunita Ranch gate at left
20.6	Turn left around stone fence corner
20.8	Sandstone probably top of Vicksburg (Warner)
21.8	Road to left to Sauz
22.4	Ranch at right cross road
22.6	Road to right to Sauz
22.7	Laureles Ranch, probably Vicksburg sandstone (Warner)
23.9	Ranch
24.0	Keep to left
24.4	Todas Santos Ranch
24.7	Bad road to right
24.8	San Jose Ranch
25.3	Road fork, take right fork
25.6	Deep arroyo, follow old telephone poles
25.9	Piedras Ranch, turn left at new white house, road straight ahead to Sta. Teresa
26.0	Keep to right, 2 roads to fields and another crosses black chert gravel hill
26.4	Road comes in from right
26.5	Road fork, take right fork
26.6	White ranch house and tank on left
26.8	Meet old road from ranch

Miles

26.9 Bad high-center road
27.9 Cross road
28.7 Pink clays
28.8 Greenish white clays and ash overlain with soft gray sandstone
28.9 Road comes from right
29.7 Turn left around fence corner
29.8 Huisachito Ranch, turn left
30.1 Black and red chert gravel
30.2 Bottom of white ash
30.3 Plugged Consolidated core well
31.1 Cross road, turn right. Green and white ash tuff Fant member Catahoula (Warner)
31.4 Black chert pebble gravel
32.0 White ash in arroyo
32.1 Road fork, take the right fork
34.0 Reynosa-Monterrey Highway. Yellow sandstone probably Soledad member of Catahoula (Warner)
35.4 Cross road
39.1 Gravel ridge, probably Catahoula (Warner)
39.4 Road from left
40.6 Cross road
40.8 Cross road brecha, concrete plug
41.2 Cross road
42.9 Turn right on Sinclair-Mercedes brecha
43.2 Turn right
43.4 Water wells and Sinclair-Mercedes Rio Bravo No. 3 and No. 4, turn left
43.5 Meet road from Javali Ranch
45.2 Turn right
45.5 Sinclair Rio Bravo No. 5. Return on same road to Monterrey highway
48.1 Reynosa-Monterrey highway, turn left (3 hours)
57.0 K-135. Same as at 34 miles above
57.7 Black chert gravel, low hills, some red-stained pebbles
59.1 Gravel ridge, red soil at top
60.4 Basal Catahoula gravel scarp, mostly black chert pebbles but few yellow weathering calcareous cobbles. Top of scarp red-stained. Road to Zacate No. 1, 5 miles south along the scarp.
61.3 Front gravel ridge, red-stained
62.2 Red-stained gravel ridge

Miles	
62.3	Top of black gumbo shale (Vicksburg)
62.4	Arroyo San Antonio
62.8	Tierra Blanca store. La Coma Ranch on south
63.5	Sandstone ridge
65.1	Sandstone ridge
65.9	White ash at base of Vicksburg. Jackson-Eocene contact. Jackson forams found in shale below this ash (Warner-Tatum). Road detours left from highway.
66.7	Thin soft sandstone of Upper Jackson
66.8	Detour crosses highway. Abundant *Operculina* found in gray shale along highway west of this intersection
68.8	Detour meets highway at K-153
69.4	Ridge
71.9	Low gravel ridge
72.5	Cross roads
74.3	Arroyo, platy sandstone
74.4	Yellow platy sandstone
75.3	Sandstone ridge
75.6	Yellow sandstone ridge (Jackson)
76.6	Arenal formation (?) (Warner-Tatum)
76.8	Zacate fault. Yegua west of fault
77.3	Brecha at southwest
78.0	Cross road
78.4	Road from Lajilla comes in from right (Yegua)
79.2	Ebonita Ranch at right
79.4	Cross road. Yellow sandstone ridge (Yegua)
80.1	Lobo ranches
80.2	Road to right
80.6	Tank along road
81.1	Arroyo Lobo at right of road
81.3	Cross Arroyo Lobo (4 hours, 30 minutes). Yegua sandstone
81.9	Good road from right
82.2	Sandstone, Yegua
82.3	Pink shale
82.4	Sandstone
83.1	Sandstone ridge, near Cook Mountain-Yegua contact
84.0	East edge of bright yellow Cook Mountain beds
84.8	Road bearing changes from S. 80 W. to west
85.3	Ranch on north
86.1	High gravel hills, calcareous pebbles
86.7	Good road to right

Miles	
86.9	Yellow Cook Mountain sandstone and clay beneath gravel
87.8	Good road from left
88.3	Good road to right, gravel hill
88.8	Good road to left
89.1	Cannon ball and calcareous concretions in yellow clay
89.9	Good road from right
90.0	Highway goes S. 30 W.
90.5	Roads from left and right
90.7	Angling cross roads
90.9	Gravel ridge
91.2	Gral. Bravo Plaza (5 hours)
92.1	Road to left over gravel hills
93.5	Soil changes yellow to gray. Cross ridge of glauconitic sandstone (Upper Mount Selman)
94.4	Upper Mount Selman sandstone
95.3	East-dipping sandstone scarp at left
95.8	Red clay shale
96.2	Arroyo Lajas. Maroon purple clay and massive gray sandstone
96.5	Enter highway from detour
98.5	China. Gasoline station
98.7	Turn right with telephone line
99.8	Left fork with telephone line off highway
100.1	Ferry across San Juan River (5 hours, 30 minutes)
100.3	Meet highway from Reynosa
101.1	Low sandstone ridge
101.6	Yellow-brown slabby sandstone, east dip
102.0	Sandstone ridge (Palafox?)
102.2	Massive yellow-brown sandstone
102.6	Yellow-brown gray 6-inch slabby sandstone
103.1	First red ridge (top of Carrizo?)
103.3	Red-brown sandstone. Cross road
103.5	Yellow-brown 6-inch slabby sandstone
104.7	Yellow-brown 6-inch slabby sandstone
104.8	Lemon-yellow calcareous concretions
105.0	Same
105.4	Yellow-brown gray slabby sandstone
105.6	Red crystalline Carrizo sandstone
105.7	Massive Carrizo sandstone. Ranch
106.0	Lemon-yellow calcareous concretions
106.2	Slabby sandstone (base of Carrizo?)
106.3	Arroyo

Miles	
106.4	Low bench (top of Wilcox?)
106.6	Top, fossiliferous Wilcox sandstone. *Venericardia* and *Ostrea thirsae*
107.6	Herreras road intersection. Fossil sandstones to here (6 hours, 45 minutes)
114.1	Cross road
116.1	Calcareous concretions
116.9	Road to right
117.7	Cross road
118.9	Platy sandstone scarp
119.5	High scarp (Loma Colorado sandstone (?))
119.9	Base of sandstone scarp, black shale
120.7	Ranch and road to right
122.5	Road to Ramones to right
126.9	Road to Ramones and Presa to right
135.6	White ranch house
140.4	Water tank
141.7	Road from San Juan on right
143.5	Railroad crossing. Monterrey-Tampico railroad
148.5	Ranch, K-279
152.1	Concrete bridge over Rio San Juan
152.5	Turn right at Hub corner
153.0	Plaza Cadereta (8 hours, 15 minutes)
160.6	Small town
172.8	Cross Rio Sta. Catarina
173.5	Pavement at steel mill gate
174.5	Industrial school
175.0	Monument
175.4	Turn left, Calle Tejada
175.9	Offset to right, keep straight ahead on Calle Gral. M. Escobeda
176.5	Cross Calle Padre Mier
176.6	Ancira Hotel on right
176.7	Turista Garage on left (9 hours)

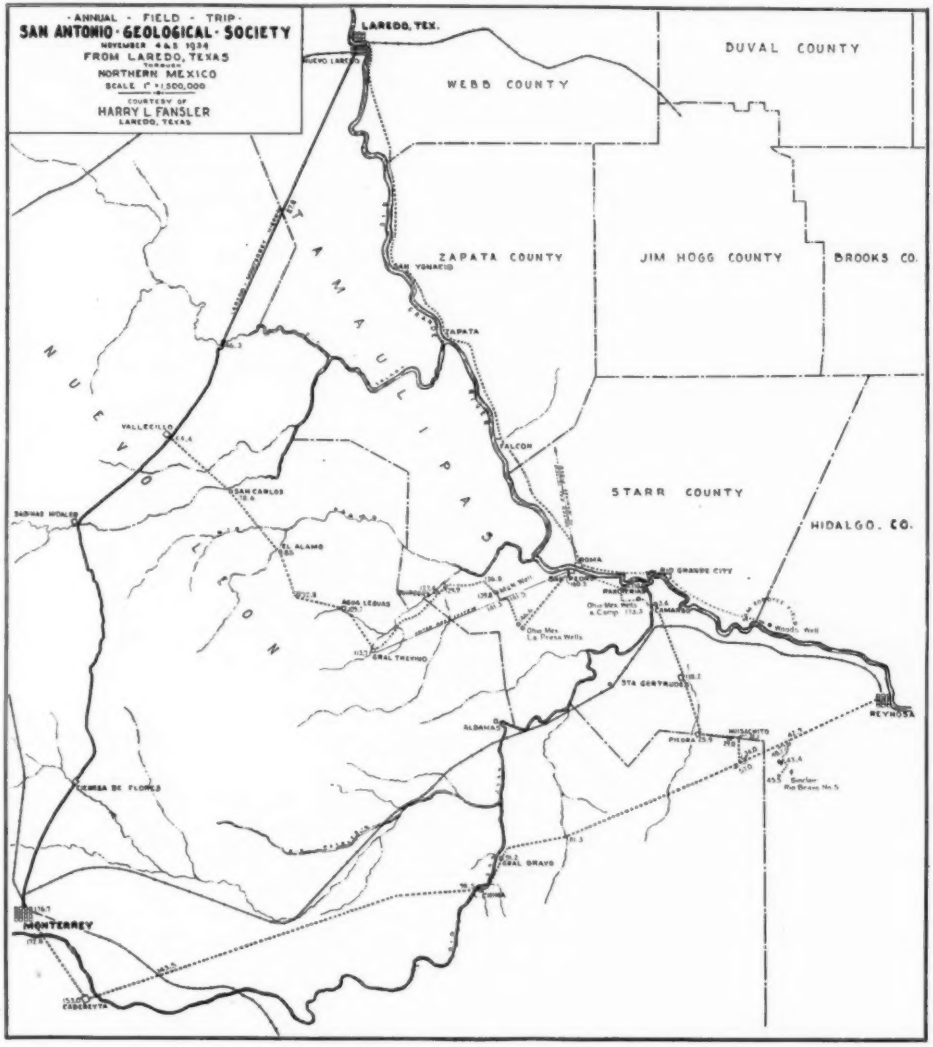

ANNUAL - FIELD - TRIP
SAN ANTONIO GEOLOGICAL SOCIETY
NOVEMBER 4 & 5 1934
FROM LAREDO, TEXAS
TO
NORTHERN MEXICO
SCALE 1" = 1,500,000
COURTESY OF
HARRY L. FANSLER
LAREDO, TEXAS
LAREDO, TEX.
NUEVO LAREDO
WEBB COUNTY
DUVAL COUNTY
ZAPATA COUNTY
JIM HOGG COUNTY
BROOKS CO.
STARR COUNTY
HIDALGO CO.
ZAPATA
FALCON
VALLECILLO
SAN CARLOS
EL ALAMO
MIER
GRAL TREVIÑO
ALBAMA
REYNOSA
MONTERREY
CADEREYTA
GRAL BRAVO
TAMAULIPAS
NUEVO LEON

FIG. 1

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 20, NO. 4 (APRIL, 1936), PP. 478-495, 2 FIGS.

GEOLOGICAL NOTES

Wells Drilled in Northeastern Mexico

Company	*Name of Well*	*State*	*Total Depth in Feet*	*Results*	*Present Status*
Carbonifera	Weekly 1	Tamps.	3,000	Dry	Abandoned
Consolidated	Banquete 1A	N. L.	1,902	Dry	Abandoned
Consolidated	Carlos Cantu 1	N. L.	2,080	Gas showing	Abandoned
Consolidated	Carlos Cantu 2	N. L.	3,852	Gas showing	Abandoned
Consolidated	Carlos Cantu 3	N. L.	6,521	Gas Showing	Abandoned
Consolidated	China 1	N. L.	2,563	Dry	Abandoned
Consolidated	Zacate 1	N. L.	5,006	Oil, gas showing	Abandoned
Consolidated	Zacate 2	N. L.	6,264	Gas showing	Abandoned
Consolidated	Zacate (3) 4	N. L.	5,447	Gas showing	Testing
Frick *et al.*	Santa Monica 1	N. L.	3,406	Oil showing	Abandoned
Frick *et al.*	Santa Monica 5	N. L.	2,260	Oil showing	Abandoned
Frick *et al.*	Santa Monica 6	N. L.	1,730	Oil showing	Abandoned
Fronteriza	Santa Anita	Tamps.	3,474	Dry	Abandoned
Humble O.&R. Co.	Guerrero 1	Tamps.	7,891	Dry	Abandoned
H. B. Kelly *et al.*	Contca Kelly	Tamps.	4,107	Oil, gas showing	Abandoned
Mercedes	Camargo 1	N. L.	5,750	Gas showing	Abandoned
Mercedes	Chancaca 1	N. L.	3,500	Dry	Abandoned
Mercedes	Chancaca 4	N. L.	3,500	Dry	Abandoned
Mercedes	Chapa 1	N. L.	5,003	Dry	Abandoned
Mercedes	Encantada 1	Tamps.	2,500	Gas showing	Abandoned
Mercedes	Sta. Gertrudis	Tamps.	297	———	Drilling
Mercedes-Sinclair	Charro 1	Tamps.	4,752	Dry	Abandoned
Mercedes-Sinclair	Charro 5A	Tamps.	5,085	Dry	Abandoned
Mercedes-Sinclair	Rio Bravo 3	Tamps.	5,006	Oil, gas showing	Abandoned
Mercedes-Sinclair	Rio Bravo 4	Tamps.	3,795	Oil, gas showing	Abandoned
Mercedes-Sinclair	Rio Bravo 6	Tamps.	4,052	———	Drilling
Mex. Govt. Petrol. Admin.	Control 201	Tamps.	3,601	Oil, gas showing	Abandoned
Mex. Govt. Petrol. Admin.	Control Camaron	N. L.	5,323	Sulphur water	Abandoned
Mex. Govt. Petrol. Admin.	Nacionales 206	N. L.	1,700	Dry	Abandoned
Mex. Govt. Petrol. Admin.	Ochoa 1	Tamps.	755	Dry	Abandoned
Mexican Gulf	San Ambrosio 1	N. L.	9,312	Hot salt water	Abandoned
Mexican Zinc Co.	Esperanzas	Coah.	3,440	Dry	Abandoned
Muñoz y Martinez	M. & M. 2	Tamps.	1,545	Gas	Producing
Muñoz y Martinez	M. & M. 3	Tamps.	1,525	Oil, gas showing	Standing
Navarro-Smith	Las Uvas 1	Coah.	910	Dry	Abandoned
Ohio-Mexico Oil	Barril Viejo 1	Coah.	3,340	Dry	Abandoned
Ohio-Mexico Oil	Cloete 1	Coah.	4,183	Gas	Acidizing
Ohio-Mexico Oil	Hinojosa 1A	N. L.	4,380	Dry	Abandoned
Ohio-Mexico Oil	La Presa 1	Tamps.	2,015	Gas	Producing
Ohio-Mexico Oil	La Presa 2	Tamps.	1,536	Gas	Producing
Ohio-Mexico Oil	Rancherias 1	Tamps.	1,271	Gas	Shut in
Ohio-Mexico Oil	Rancherias 2	Tamps.	2,030	Oil, gas showing	Abandoned
Ohio-Mexico Oil	Rancherias 3	Tamps.	1,954	Gas with oil	Shut in
Ohio-Mexico Oil	Rancherias 4	Tamps.	835	Gas	Drilling
Ohio-Mexico Oil	Treviño 1	Coah.	5,920	Dry	Abandoned
Ohio-Mexico Oil	Zambrano 1	Coah.	4,430	Dry	Abandoned
Plaza & Devine	Guimbarda 2	Tamps.	1,100	Dry	Abandoned

William G. Kane

OUACHITA BOULDER PROBLEM

INTRODUCTION

The shale that contains the unusual boulders in the Ouachita Mountains in Oklahoma and western Arkansas is interbedded between the Carboniferous Stanley-Jackfork sequence below and the Lower Pennsylvanian Atoka formation above in several synclines in the western end of the mountains. Besides being in these synclines, boulders are in shale at many exposures along the north flank of the Ouachitas from near Atoka, Oklahoma, to near Boles, Arkansas. Further discussion of the problem of the precise age of this shale and the name it should bear is not necessary for this paper. The accompanying map (Fig. 1) shows the exposures of boulder beds. The boulders were long thought to be exotic, but to-day most students who have considered the problem believe that they were derived from the Ouachita region.

THEORIES OF SOURCE

Ice rafts.—As most of the Older Paleozoic boulders—notably those of Ordovician limestone—are composed of Arbuckle-like rocks that were not known to crop out in the Ouachitas, they were long thought to be exotics rafted into the Ouachitas by berg or floe ice. But the Younger Paleozoic boulders are of Ouachita rocks, and the Middle Devonian cherty limestone (Brushy Creek or Pinetop chert, the equivalent of the lower division of the Arkansas novaculite), recognized in some of the boulders, is not known from anywhere else but at the Brushy Creek inlier which is on the north flank of the Ouachitas. Recently some of the boulders from the bed near Boles, Arkansas, have been recognized[1] to be composed of Ozark-like rocks. Scratches that are on some of the boulders are now recognized, seemingly by everyone who has studied them, as being of diastrophic—not glacial—origin, caused by one boulder gouging another during orogeny long after the boulders got into their beds.

Objections to the hypothesis that foreign boulders were rafted into the Ouachita region and dropped into the shale area: (1) that it is a reasonable assumption that all the boulders came from the same region, and thus the fact that three flotillas of ice rafts would have been required to transport some boulders from the region to the south of the Arbuckles, others from the Ozarks, and still others from localities within the Ouachitas themselves, reduces this explanation to an improbability; (2) that ice very rarely, if ever, transports

[1] Josiah Bridge in H. D. Miser, "Carboniferous Rocks of Ouachita Mountains," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 18, No. 8 (August, 1934), pp. 997–99.

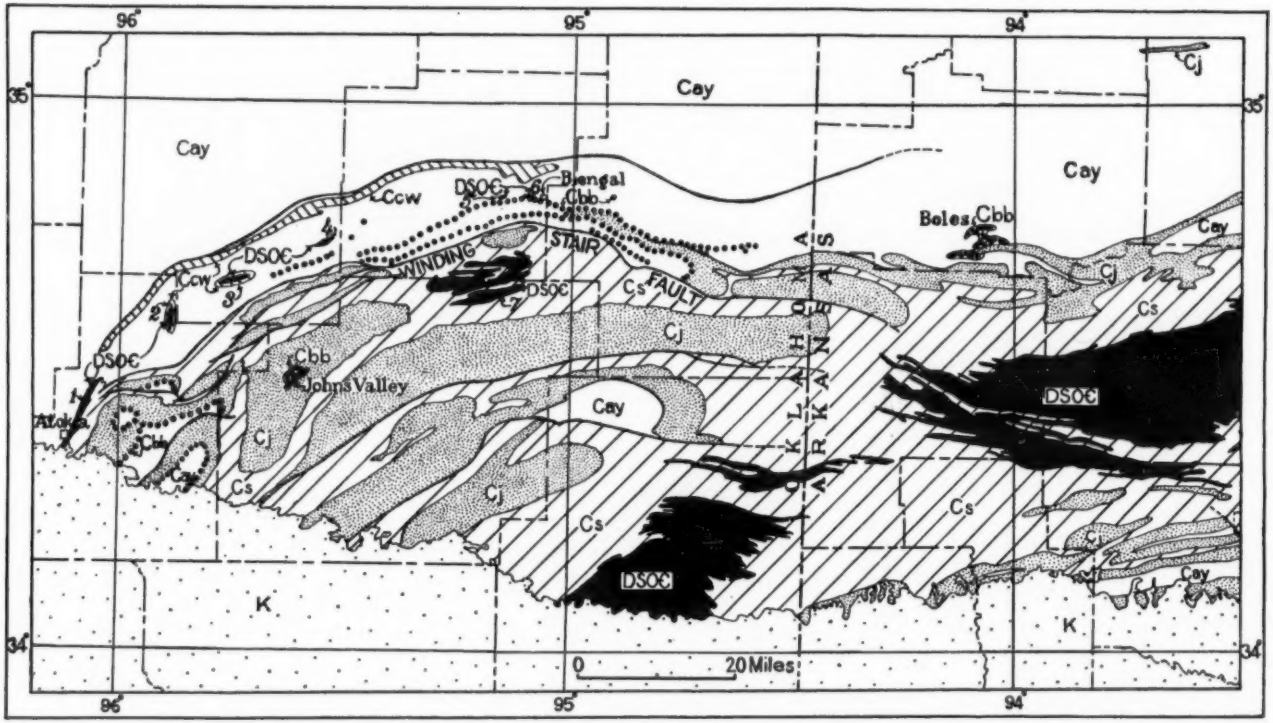


FIG. 1.—Geologic map of part of the Ouachita Mountains of Oklahoma and Arkansas. Stratigraphic divisions: *DSOЄ*, Devonian, Silurian, Ordovician, and Cambrian rocks including all divisions of the Arkansas novaculite; *Cs*, Stanley shale (Carboniferous); *Cj*, Jackfork sandstone (Carboniferous); *Cbb*, boulder beds (Carboniferous); *Ccw*, Caney shale and Wapanucka limestone (Carboniferous); *Cay*, Atoka formation and younger Pennsylvanian rocks; and *K*, Cretaceous and younger rocks. Inliers of Bengalia: *1*, Black Knob Ridge; *2*, Wesley; *3*, Brushy Creek; *4*, seven miles south of Hartshorne; *5–6*, west of Bengal; and *7*, Potato Hills.

boulders so large as any one of the four great masses of Ordovician limestone that are in Johns Valley; (3) that if it be granted that ice rafts ever get such huge boulders into them, probably four such huge masses would not have been dropped all in an area so small—and only there, so far as known—as the 10-square-mile Johns Valley locality; and (4) that both the region south of the Arbuckles and the Ozarks—hypothetical sources of exotic boulders—are many miles from the boulder localities, and beyond strata which are of the same age as the boulder beds but which contain no boulders.

Overthrusts.—Hypotheses that the boulders are remnants of overthrust sheets very plausibly account for long-distance transportation—if such transportation actually took place—but the boulders themselves—if their testimony may be admitted—afford the only evidence that low-angle overthrusting took place in the Ouachitas before the boulders got into their beds.

"Pre-Ouachita uplift."—Powers[2] suggested that the boulders might have come from a hypothetical "pre-Ouachita uplift" that formed a "high" land during post-Jackfork and pre-Atoka time along the north flank of the Ouachita region. This hypothesis of the source of the boulders has been espoused and developed by several other geologists.

Some objections to this hypothesis of source are as follows.

1. "Some 20 miles"[3] seems too great a distance for a submarine landslip, for through it may be conceivable that masses of rock, even of mountainous size, may slide down slopes that are sufficiently steep—down piedmont slopes in front of burgeoning mountains, for example—it is not so conceivable that epicontinental geosynclines have ever got so deep as to afford a slope of even 3 degrees into them for a distance of 20 miles. Such geosynclines probably warp down progressively as they are filled with sediments which are deposited near sea-level. A trough with a slope of 3 degrees into it for 20 miles would be more than a mile deep. The Brashears "boulder," 370 feet in length of exposure,[4] which is in the southeast part of Johns Valley, is 12 miles southeast of the nearest point on the Winding Stair fault across a faulted terrane of Stanley and Jackfork. Boulders in southeastern Atoka County, Oklahoma (Sec. 20, T. 3 S., R. 14 E.), the

[2] Sidney Powers, "Age of the Folding of the Oklahoma Mountains," *Geol. Soc. Amer. Bull.*, Vol. 39 (1928), p. 1044.

[3] R. C. Moore, "The Origin and Age of the Boulder-Bearing Johns Valley Shale in the Ouachita Mountains of Arkansas and Oklahoma," *Amer. Jour. Sci.*, 5th ser., Vol. 27 (1934), p. 448.

[4] Miser, *op. cit.*, p. 996.

farthest of all known from the supposed location of this hypothetical land area, are 15.5 miles southeast of the nearest point on the Winding Stair fault. As these distances are actual and are not estimates of what they were before crustal shortening, "some 20 miles" is probably a reasonable estimate of the maximum submarine distance that some boulders must have moved according to the hypothesis that they came from this "pre-Ouachita uplift."

2. If the Jackfork sandstone extended northward in Oklahoma and western Arkansas across the place where this hypothetical land rose later—as it does extend northward into the Arkansas Valley in the region east of Boles, Arkansas—probably there would have been little shale for the boulders to be in, for sand grains, derived from this thick sandstone, probably would have been more abundant than mud particles in the sediments deposited along the front of the hypothetical "high" mountains.[5]

3. Only a part[6] of Morrow time seems too brief for both the growth and the truncation of "high" mountains. The Rocky Mountains are not so new; yet they are still high. The Arbuckle Mountains received several pushes throughout Pennsylvanian time; yet granite pebbles are not known in sediments derived from them in beds younger than the Lower Permian Pontotoc.[7]

Bengalia.—My explanation[8]—that the boulders came from a land, Bengalia, that was located along the north flank of the Ouachita region—differs only in detail from the explanations of those who believe that the boulders came from the "pre-Ouachita uplift." I concluded that the boulders were distributed by submarine landslips, and that Black Knob Ridge and the Potato Hills as well as the inliers in Ti Valley and near Bengal are inliers of this land. Miser[9] has since stated that "the exposures of Caney shale and older rocks in the Ti Valley-Choctaw belt may represent partially revealed portions of this mountainous area" (Powers' "pre-Ouachita uplift").

But I do not have any idea how high Bengalia rose, and know of no reason why it might not have been a low land at times and an archipelago of low islands during the time of deposition of the boulder beds. However, I am convinced that this land formed a barrier along the north side of the filter-basin-like Ouachita trough during the

[5] See Moore's Figure 4, *op. cit.*, p. 439.

[6] *Ibid.*, pp. 449–52 and Fig. 4.

[7] Powers, *op. cit.*, p. 1049.

[8] "Boulders from Bengalia," *Jour. Geol.*, Vol. 41 (1933), pp. 590–621.

[9] *Op. cit.*, p. 1003.

Stanley-Jackfork epoch and confined these two thick formations to the geosyncline in Oklahoma, though the Jackfork filled the trough in part of Arkansas and overflowed into the Arkansas Valley.

Boulders might have moved in submarine landslips a few miles into a rapidly subsiding trough to the south of this land, but the boulders in the synclines in the western end of the mountains that are 10–15 miles from the Ti Valley region probably came from a nearer source, and I suggested that they came from near-by buried hills.[10]

Since the publication of my explanation, Miser[11] has pointed out that only four limestone "boulders" larger than 60 feet in greatest dimensions of exposure are known in all the Ouachita Mountains. Their greatest dimensions of exposure are 150, 195, 220, and 370 feet. These four great masses are all in the 10-square-mile area of Johns Valley, all are of the same formation, Bromide, and the strike of the bedding is the same in them all. Miser reports that three of these masses dip "east," and that the fourth, which "dips steeply," strikes "north." These data convince me that these four masses of rock are inliers that have roots—not "boulders" at all. For even though it be admitted that nothing is indicated by the presence of the only four "boulders" so great in size in the one small locality, it is entirely improbable that these four masses—if they were random boulders that were transported into position—would all have exactly the same strike. If the Mississippian part of the Caney shale is eventually proved to be older than the Jackfork sandstone, great masses of this part of the Caney—like those mentioned by Miser,[12] 500 and 600 feet long—some of which appear to lie stratigraphically above Jackfork, will also probably prove to be inliers.

Also since the publication of my explanation, Decker[13] has reported the discovery in the Black Knob Ridge inlier—of Bengalia—of Viola limestone and Sylvan shale. This first discovery of Arbuckle-like Older Paleozoic rocks in place in the Ouachitas indicates that the boulders are not exotic but that they came from a Ouachita source. For the Viola and Sylvan are two of the five Older Paleozoic formations recognized by Ulrich[14] in his large collection of boulders from the

[10] *Op. cit.*, p. 615 and Fig. 5.

[11] *Op. cit.*, pp. 995–96.

[12] *Ibid.*, p. 999.

[13] C. E. Decker, "Viola Limestone, Primarily of Arbuckle and Wichita Mountain Regions, Oklahoma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 17, No. 12 (December, 1933), pp. 1405–35.

[14] E. O. Ulrich, "Fossiliferous Boulders in the Ouachita 'Caney' Shale and the Age of the Shale Containing Them," *Oklahoma Geol. Survey Bull. 45* (1927).

Oklahoma Ouachitas. And the Bromide is a third such formation.

Thus, new evidence substantiates the concept of Bengalia.

WILLIAM KRAMER

BALLINGER, TEXAS
January 16, 1936

Mr. Kramer's note on the boulders of the Johns Valley shale and the structure of the Ouachita Mountains deals with an interpretation offered by him in 1933, and its relation to the evidence which has since accumulated. This interpretation is decidedly at variance with those which had been made previously, but I am told that recently some of the other geologists working in the region have accepted many of his views. Since the line of argument in the previous article may not be familiar to all, it might be well to restate it here.

1. Contrary to the previous interpretations, no overthrusts are believed by Kramer to exist in the Ouachita Mountains. The faults of the region are considered to be steeply dipping, and perhaps to be normal faults. The Paleozoic rocks of the region consist of two distinct facies, the Ouachita and the Arbuckle, whose exposures now lie closely adjacent, but which are interpreted by many geologists as having been laid down far apart, and later brought together by overthrusting. If overthrusting does not exist, some other explanation must be sought to explain this contrast in facies.

2. It is therefore assumed by Kramer that the older Paleozoic rocks of the Arbuckle facies extend into the Ouachita Mountain region, where they are covered by Pennsylvanian clastic rocks. Some outcrops of the older Paleozoic exist in the region, but instead of being of the Arbuckle facies they consist of slates, cherts, and novaculites, typical of the facies exposed elsewhere in the Ouachita Mountain region. Kramer assumes, however, that these are of local extent, and that they grade down the dip into rocks of Arbuckle facies. Their character is supposed to result from conditions of sedimentation marginal to a postulated land, "Bengalia." (Some other geologists say even that the exposed rocks actually are of Arbuckle facies, and that the difference in character results entirely from silicification and other surface alteration.)

3. According to Kramer the boulders of the Johns Valley shale are therefore autochthonous, rather than exotic. In other words, instead of having been transported from uplifts outside of, or marginal to, the Ouachita basin of deposition, they came from uplifts raised within the geosyncline itself, and immediately adjacent to the outcrops of the boulders.

4. Large boulders occur, however, in Johns Valley, a synclinal

basin far from any known axes of uplift. The synclinal structure of this district is assumed by Kramer to be superficial only, and to mask a buried hill of older rocks of Arbuckle facies, toward which the Stanley and Jackfork formations now dip. Since the measured thicknesses of these formations reach from 5,000 to 10,000 feet, such a hill would seem to be of mountainous proportions. It is therefore assumed that such measurements of thickness are unreliable, and that a part of the dip in these formations is an original sedimentary feature. "It is probable . . . that nowhere was the Stanley-Jackfork succession deposited in a thickness greater than a fourth to a half of the measured thickness of these strata" (Kramer, 1933, p. 615).

Extensive discussion of the interpretations offered by Kramer and previous geologists is unnecessary at this time, because the geology of the region will probably soon become far better known than it is now. Aside from Honess's careful work in the southeast part of the Oklahoma area, the only extensive mapping of the area was that done thirty years ago by Taff, when the problems of the region were not so well appreciated. Since that time, detailed work in the area has been scattered, and has been seriously hampered by the heavy forest cover and other obstacles. This condition is now being remedied. Aerial mosaic maps of the region have been made, and the surface features are being studied by oil company geologists and parties of the U. S. Geological Survey. Soon the geological features will be checked by geophysical studies, and still more accurately by the drill. Discussions of underground conditions will then pass from mere speculation, to deductions based on a mass of observed facts.

Until that time comes, however, geologists such as myself who are not familiar with the region will be tempted to compare the Ouachita Mountains with the Appalachians, the Rockies, and other regions of strong deformation, and therefore to conclude that theories which call for overthrusting are more plausible than those which reject such an interpretation. We would not be inclined, as Mr. Kramer seems to be, to consider the boulders themselves as the only evidence for overthrusting that exists. We would not necessarily, however, follow Van der Gracht and Ulrich in assuming that the roots of such thrusts originated south of the Sabine uplift, or from beneath the present Gulf of Mexico. Such interpretations doubtless have their appeal to a disciple of Wegener, but are not a necessary consequence of the overthrust theory.

In his present note, Mr. Kramer does not consider the possibility of overthrusting, except as a means of direct transportation of the boulders. Transportation of the boulders by thrusting has been postu-

lated only by Van der Gracht, but others who have studied the boulders in the field are inclined to consider them as having been laid down in their present positions by sedimentary processes. Other implications of the overthrust theory are not considered, and they may be important. Thus, if we were to assume with Miser that the exposures of Pre-Pennsylvanian rocks at Brushy Creek and near-by localities lay to the north of the Ti Valley overthrust zone, the homogeneity of Kramer's "Bengalia" would largely disappear. The presence of true Caney shale in this region, as distinguished from the younger Johns Valley shale which had previously been confused with it (Miser, 1934, pp. 975–77), necessitates extensive revisions in Kramer's original interpretation, which he has not made in his present note. Kramer can say with justice that the boulders came from the Ouachita Mountain region, but he fails to point out that they came only from that part of the Ouachitas which contain a facies of rocks like that exposed north of this assumed fault zone.

Viewed in the light of other overthrust regions, Kramer's arguments in favor of normal faulting in the region are not at all convincing. Normal faults coming later than the folding are not likely to follow the previous grain of the rocks so closely as the faults do in the Ouachita Mountains. Thus in southeastern Pennsylvania, the folded Paleozoic rocks were extensively shattered by normal faults during Triassic time, or not much later than the folding. Here, recent careful mapping shows that their trends and patterns, although roughly accordant with the previous grain, are quite discordant in detail. Moreover, I am told that overturning and squeezing of the beds is a common feature near many of the faults in the Ouachitas, and such features, if related to the faults, as they seem to be, could only have been produced by compression. The lack of dip measurements on observed fault planes, which Kramer emphasizes in his earlier article, is purely negative reasoning, and is partly due to the lack of careful field work in critical areas, a condition which will be corrected with time. Thus I am told that recent field work has shown that exposures of fault planes with a low angle of dip have been discovered in recent detailed work on Black Knob Ridge. Extensive normal faulting in the region would seem to be definitely ruled out.

The distinction between steep and gently dipping thrust faults in the area is less plain. Kramer criticizes the overthrust interpretation because "outlying klippen and peninsula-reëntrant outcrop patterns of overthrust masses" such as shown on the Rome folio in Georgia are unknown (1933, p. 608). Such features are, of course, valuable in interpreting the geology, but they do not necessarily have to exist,

as an examination of dozens of other Appalachian folios, dealing with strongly folded and overthrust regions, will show. In many of the other folios, the surface features closely resemble those in the Ouachita Mountains. It should be remembered also that wide areas in the Ouachitas still need critical work, and that klippen and other overthrust features may eventually be discovered by careful discrimination in areas of yet undifferentiated clastic rocks.

To an outsider, Kramer's explanation of the structure of Johns Valley is far from convincing, even if supported by pressure-box experiments. His argument that large boulders are "all in the 10-square-mile area of Johns Valley" is negative reasoning. How do we know what boulders have been removed by erosion, along with their shale matrix, in the anticlinorial areas, and how do we know what boulders still lie beneath the surface in the synclines? I am told that recent work has disclosed the existence of boulders equally large in synclinal patches outside of Johns Valley. Would Mr. Kramer put a buried hill under each of these? His effort to discount the reliability of dips in the Stanley and Jackfork formations is supported by no evidence, and seems to be resorted to merely to reduce the implausibility of his theory. As a matter of fact, as shown by the recent aerial mosaic maps, the bedding planes in the Jackfork are even and regular over enormous areas, and field work which has made use of these maps discloses the fact that the Jackfork may be subdivided into widely traceable members. Such conditions would certainly not obtain if the Jackfork had been so irregularly deposited that its true thickness was only "one-fourth to one-half" its apparent thickness.

The problem of the origin of the boulders in the Ouachita Mountains in an intriguing and perplexing one. Some, and perhaps most, of their mystery will disappear with future careful field work. At present, however, it would seem that to reject the interpretation of overthrusting as the cause of the structure and of the distribution of the facies will eliminate some difficulties, but will lead the theorist into other difficulties equally profound. The plain truth is that we do not know how the boulders got into their present position. We know that they are there, and that we need many more facts before they can be adequately explained.

PHILIP B. KING

U. S. GEOLOGICAL SURVEY
WASHINGTON, D. C.
January 29, 1936

Long faults of the Oklahoma Ouachitas.—Though a predominance of evidence doubtless indicates that the long faults of the Oklahoma

Ouachitas are thrusts, the steep dips on the upthrow sides of their traces also doubtless indicate that their surfaces are likewise steeply dipping. Obviously thrust faults, even those having no higher angle than the average of 36 degrees, must effect stratigraphic displacements of many miles in order to effect horizontal displacements of many miles—such as the displacements postulated by those who believe that Ouachita rocks were thrust close to Arbuckle-like rocks. The undulatory and very low-angle or nearly horizontal overthrusts that have effected horizontal displacements of many miles in many parts of the world do not have nearly straight traces like those of the long faults of the Ouachitas but show curved or peninsula-reëntrant traces and outliers of the overthrust sheets. Such outcrop patterns are well-known features of these kinds of faults in the Appalachians, the northern Rockies, the Alps, the Scottish Highlands, and Norway.

Little is known of the dips of thrust-fault surfaces with depth; experimental evidence is contradictory.[15] Well data from the Turner Valley oil field show that some thrust faults dip steeply downward near the erosion surface, dip less steeply downward farther back, and dip more steeply downward still farther back.[16] But the Ouachitas are now very much lower than they once were, for they were truncated by pre-Cretaceous peneplanation after the orogeny. Accordingly, the present outcrops of the long faults were once deep, so that if the fault surfaces formerly had flatter parts, these parts have probably been eroded.

As a hypothetical long fault in Ti Valley—postulated as being the boundary between the rocks laid down in the geosyncline and the Arbuckle-like rocks—would probably be like the other long faults of the Ouachitas, one wonders how it might have brought the two facies appreciably closer together, for such a fault would have the Atoka formation on both sides of its trace along its whole length, thus indicating that the maximum horizontal and stratigraphic displacements would each be about one mile.

Juxtaposition of Arbuckle-like rocks and rocks deposited in the Ouachita geosyncline.—Obviously the Stanley and Jackfork formations must be classed as having been deposited in the Ouachita geosyncline. In fact they are the initial deposits of the geosyncline as such, and constitute about ⅔ of the thickness of the geosynclinal facies. Obviously, too, the Viola limestone and the Sylvan shale must be classed as Arbuckle-like. Yet the Stanley laps without a fault contact on Black Knob Ridge, which is nowhere more than a mile and

[15] C. K. Leith, *Structural Geology* (1923), pp. 91–92.

[16] P. D. Moore, oral communication, January, 1934.

a quarter wide, and on which the Viola and Sylvan crop out. The Jackfork lies on the Stanley, so that it is separated from the ridge only by the Stanley outcrop which is 2–3 miles wide. Thus the theorist's need of a long-distance overthrust evaporates. Probably the relations between the Stanley and the older rocks are like this all along the north flank of the Ouachitas along the south side of Bengalia which formed the northern boundary of the geosyncline, but the northernmost Stanley and Jackfork are hidden beneath the younger rocks along the remainder of the north flank of the mountains.

Change of facies is well established by the outcrops of Viola and Sylvan in Black Knob Ridge and the Brushy Creek or Pinetop cherty limestone in the Brushy Creek inlier.

I have not seen the exposures of Viola in Black Knob Ridge, but as Decker called them limestone, presumably that is what they are—not "slates, cherts, and novaculites."

Buried hills or mountains.—King[17] has shown a sketch of observed stratigraphic relations which probably illustrates how the Ouachita boulders got into their beds. A Permian boulder bed is shown overlapping on a hill or mountain of Cambrian and Ordovician strata. Some of the boulders, which are Ordovician, are apparently about half a mile from their source in the hill. The contact of the boulder bed with the older rocks dips away from the hill more steeply than does its top, and successively younger beds dip successively less steeply away from the hill, thus indicating that still higher beds deposited about as high as or higher than the top of the hill might have dipped toward the hill if that was the direction of the regional depositional dip.

Dips in the Jackfork seem very reliable; which fact does not indicate that they may not be partly depositional. The idea that measured thicknesses of strata may not always be so great as they seem is too long and well established to require further comment.

Probably no Ouachita boulder moved many miles from its source. All the known boulders are along the north side of the mountains; none is known in the Boktukola syncline in the interior where the apparently continuous succession represents much more than all the time during which boulders were deposited.

The four great masses of limestone in Johns Valley seem to be inliers not only because such great masses of limestone are known in that small place alone, but also because they are all composed of the same formation, and most of all because they all have the same strike.

[17] P. B. King, "Permian Stratigraphy of Trans-Pecos Texas," *Bull. Geol. Soc. America*, Vol. 45 (1934), Fig. 3B, p. 717.

History of time from Mississippian Caney until Atoka.—If the Mississippian part of the Caney shale is older than the Stanley and Jackfork formations—which some geologists still doubt—the Stanley, Jackfork, and boulder-bearing "Johns Valley" shale, as well as the upper Caney or Springer and the Wapanucka limestone, all seem to be Morrow. The "Johns Valley" at some places seems to be younger than some of the Morrow, and appears to be, at least partly, the equivalent of the Wapanucka.

According to these tenets, the Ouachita geosyncline began its history as a region receiving thick deposits after the deposition of the Mississippian Caney in the northern part of the Oklahoma portion. Relatively, the geosyncline warped down as Llanoria and Bengalia warped up, possibly with the formation or initiation of horst and fault-scarp hills or mountains in Bengalia. The Stanley and Jackfork sediments, mostly from Llanoria, rapidly filled the geosyncline as it warped down. Deposition of coarse clastics continued through Jackfork till after all or some of Atoka time in the southern part of the geosyncline in Oklahoma near Llanoria, as is evidenced by the thick Jackfork-Atoka sandstone in the Boktukola syncline.

In "Johns Valley" time perhaps the northern part of the geosyncline in Oklahoma warped down faster than it was filled with sediments from much eroded Llanoria, but sandstones called Jackfork filled or had already filled the geosyncline in part of Arkansas and overflowed into the Arkansas Valley in the region east of Boles. The boulders from Bengalia were deposited during this time, probably distributed by submarine landslips that may have been provoked by earth tremors that accompanied down-faulting or down-warping of the geosyncline along the south side of Bengalia. The usual lateral gradation of sediments was deposited during "Johns Valley" time, with sandstone near Llanoria, shale farther from it, and Wapanucka limestone still farther away.

Atoka sediments subsequently buried most of the remaining peaks in Bengalia, only a few of which have since been disclosed by erosion.

WILLIAM KRAMER

February 11, 1936

Mr. Kramer holds to the belief that there is a juxtaposition of Arbuckle-like rocks to the rocks deposited in the Ouachita geosyncline. Specifically, he mentions the occurrence of Viola limestone and Sylvan shale in Black Knob Ridge at the west end of the Ouachita Mountains as establishing the presence of Arbuckle-like rocks in the Ouachita area. The Viola limestone and Sylvan shale, both of Ordovician age, are widespread and typically developed in the Arbuckle Mountains. The results of a detailed geologic examination of

Black Knob Ridge in the fall of 1935 by Josiah Bridge, T. A. Hendricks, and M. M. Knechtel, of the United States Geological Survey, demonstrate that the rocks of Black Knob Ridge belong to the Ouachita facies and are dissimilar in many features from the sequence of the Arbuckle Mountains. This subject, with special reference to the pre-Carboniferous rocks of Black Knob Ridge, will be discussed fully in a paper that the above-named geologists are planning to present at the Tulsa (1936) meeting of the American Association of Petroleum Geologists.

HUGH D. MISER

WASHINGTON, D. C.
February 17, 1936

DISTRIBUTION OF EOCENE ROCKS IN SANTA LUCIA MOUNTAINS, CALIFORNIA

Until recently it was supposed that strata of Eocene age in the Santa Lucia Mountains are confined to the southern part. Recent discoveries of sediments bearing Eocene marine faunas furnish evidence for widening the extent of Eocene seas in the central Coast Ranges.

Lower Eocene beds (Martinez formation) were reported by Edwards[1] from the southern Santa Lucia Mountains (Adelaida and Bryson quadrangles). More recently Reiche[2] found the Martinez formation to be present in the central part of the mountains (Lucia quadrangle). The Carmelo series at Point Lobos (Carmel Bay, at the north end of the Santa Lucia Mountains) previously assigned to Upper Cretaceous (?) age by the writer,[3] may now be more definitely correlated with the Lower Eocene, thanks to the discovery of *Turritella* cf. *pachecoensis* Stanton by R. A. Bramkamp.[4] This evidence, although admittedly not conclusive, is better than that upon which the earlier assignment was made. Thus Lower Eocene strata are known in the southern and central part and fairly well established in the northern part of the Santa Lucia Mountains.

The occurrences of Upper Eocene beds in the Santa Lucia Mountains have not been noted heretofore. In the headwaters of the Carmel River and the Arroyo Seco (Jamesburg and Lucia quadrangles) there is a series of massive sandstones, siltstones, and conglomerates resting

[1] M. G. Edwards, "Some Eocene Localities in Salinas Valley District, California," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 17, No. 1 (1933), p. 81.

[2] Parry Reiche, "Geology of the Lucia Quadrangle, California," Ph.D. thesis, *Univ. California Dept. Geol. Sci.* (1934).

[3] C. L. Herold, "Fossil Markings in the Carmelo Series (Upper Cretaceous [?]), Point Lobos, California," *Jour. Geol.*, Vol. 42 (1934), p. 631.

[4] Personal communication.

with depositional contact on the Sur schists of the Santa Lucia basement complex, and attaining an approximate thickness of 600 feet. These beds occur in two narrow bands trending N. 40° W. Beginning near Tassajara Hot Springs, the southern belt continues northwestward to the Carmel River, occupying a large part of Church Creek valley; the northern belt parallels the former and follows the course of Miller Creek. Thrust faults form the northeastern boundaries of both occurrences, and along these the Sur schists have overridden the

FIG. 1

sediments from the northeast. Reiche[5] and the writer agreed on a tentative correlation of these beds with the Lower Miocene (Vaqueros formation) without benefit of faunal evidence. However, the subsequent discovery of a microfauna now permits a correlation with the basal "Gaviota formation" of Effinger[6] and Schenck and Reinhart[7] at Gaviota Pass north of Santa Barbara. *Bulimina sculptilis* Cushman, and *Plectofrondicularia packardi* Cushman and Schenck[8] are the diag-

[5] Personal communication.

[6] W. L. Effinger, "Gaviota Formation of Santa Barbara County, California," abstracts of meeting, Cordilleran Section, *Geol. Soc. America* (1935), p. 36.

[7] H. G. Schenck and P. W. Reinhart, "Foraminifera from the Gaviota Formation of California," *ibid.*, p. 35.

[8] Foraminiferal determinations were made by Boris Laiming through the courtesy of R. D. Reed, chief geologist of The Texas Company, Los Angeles, California, for which the writer makes grateful acknowledgment.

nostic species on which the correlation was based. Schenck and Kleinpell[9] have recently referred this fauna to the Refugian stage, Upper Eocene or Lower Oligocene of Europe, or post-Tejon (restricted) of California.

In the Point Sur quadrangle, 12 miles northwest, there is a sedimentary sequence of similar lithologic character, like thickness, and exactly the same structural relationships as those already described. Trask,[10] lacking faunal evidence, tentatively assigned these beds on Palo Colorado Creek to Upper Cretaceous (Chico formation). The writer is not aware of any subsequent faunal collections or determinations from this locality. However, there can be little doubt that the beds are contemporaneous with those of the Jamesburg-Lucia region, not only on account of the similarities already noted, but primarily because of the like relationships to the same thrust zone.

Still more occurrences will undoubtedly be brought to light in the Santa Lucia Mountains when a detailed study of the Junipero Serra quadrangle (southeast and east of the Jamesburg and Lucia quadrangles, respectively) is made.

Turning now to the regional and paleogeographical significance of the foregoing discussion, we find that the area west of the Salinas Valley, from Monterey Bay south to San Luis Obispo, has been generally considered as a land mass during the Eocene epoch. Reed,[11] however, suggested that Salinia, a paleogeographic province possessed of a granitic basement, now bounded by the San Andreas and Nacimiento fault systems (Fig. 1)

> . . . may have remained for the most part above sea level, but part of it was flooded, and the rest may have been during part of the (Eocene) epoch. If so, the deposits were largely removed before Miocene deposition began in the same area.

Evidence is now at hand to support the foregoing statement in a large measure, and it is possible to enlarge the extent of the Eocene seas over the greater part of Salinia.

The San Juan Bautista formation and questionably the Pinecate formation of the area between the Gabilan Range and the Santa Cruz Mountains (San Juan Bautista quadrangle) have been assigned to the Refugian stage by Schenck and Kleinpell,[12] and this occurrence is plotted on the accompanying map (Fig. 1). Also shown on the map

[9] "Refugian Stage of Pacific Coast Tertiary," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 20, No. 2 (February, 1936), pp. 218–19.

[10] P. D. Trask, "Geology of Point Sur Quadrangle, California," *Univ. California Pub., Bull. Dept. Geol. Sci.*, Vol. 16, No. 6 (1926), p. 143.

[11] R. D. Reed, *Geology of California* (Amer. Assoc. Petrol. Geol., 1933), p. 146.

[12] *Op. cit.*

are two localities from the Santa Cruz Mountains[13] to complete the picture of distribution of Eocene rocks on Salinia.

As far as is known, Lower and Upper Eocene rocks are not in contact within this province. In the south and central parts the Lower Eocene rests on Cretaceous, and in the north on the Basement complex; the Upper Eocene, so far as established, rests solely on the Basement complex in the central and northern Santa Lucia Mountains, or central-western Salinia.

In the Eocene conglomerates of the Adelaida, Bryson, Lucia, and Jamesburg quadrangles, and at Point Lobos are abundant and large pebbles of a porphyritic volcanic rock, the source of which is not definitely established in any of the pre-Eocene rocks of the Coast Ranges. These exotic pebbles suggest a western source. Moreover, the type and nature of sediments accompanying the conglomerates are such as to suggest a near-shore environment.

C. LATHROP HEROLD

SHELL PETROLEUM CORPORATION
HOUSTON, TEXAS
February 26, 1936

"POTAMIDES MATSONI" ZONE OF TEXAS (BURKVILLE BEDS)

In 1913 W. H. Dall[1] described a brackish water fauna from the Pliocene of the southern Coastal Plain. In the collection were fossils sent to him by Vaughan and Matson from localities on the south side of Cow Creek about 1–1.5 miles from the town of Burkville, Texas. G. C. Matson furnished the following information.

> The black clay found at this locality is not confined to the vicinity of Burkville for it extends southward about four miles and is reported some distance north of town. This clay may be traced into western Louisiana where it forms the Anacoco prairies. By means of scattered outcrops it is possible to determine its occurrence several miles east of the Texas-Louisiana boundary.

Other localities from which the same fauna was collected were 4 miles south of Atkinson, Wayne County, Georgia, on the Satilla River, also in Louisiana in Rapides Parish on the Frank Muse place, and from the depth of 49 feet in a well in the NE.¼, Sec. 28, T. 3 N., R. 2 W., 6–8 miles southwest of Alexandria, Louisiana.

Dall stated:

> The interest of this fauna lies not only in its being strictly brackish water and containing a large number of hitherto unknown species, but in its wide distri-

[13] J. C. Branner *et al.*, "The Santa Cruz Quadrangle," *U. S. Geol. Survey Folio 163* (1909).
A. C. Lawson, "The San Francisco Folio," *U. S. Geol. Survey Folio 193* (1914).

[1] W. H. Dall, *Proc. U. S. Geol. Survey Nat. Museum*, Vol. 46 (1913), pp. 225–37.

bution along the edge of the Pliocene Coastal Plain, forming a faunal horizon hitherto unrecognized.

A list of the species found in this horizon is given in the *U. S. Geol. Survey Water Supply Paper 335* (1914), "Geology and Underground Waters of the Southeastern Part of the Texas Coastal Plain," p. 73, by Alex. Deussen. Dall thought they were probably Pliocene. Out of the 35 species 29 were new species.

This zone was recognized as early as 1902 when Veatch[2] suggested the name "Burkville beds" and gave a section of Boggy Branch Bluff on the Sabine River and said this was a continuation of the black-land belt in which fossils occurred at Burkville.

In 1918 Dumble[3] recorded in his report C. L. Baker's description of these beds at Burkville. As to the age Dumble stated that in addition to the invertebrate fauna which Dall thought to be Pliocene in age, a few mammalian bones were found which were identified by W. D. Matthew as late Miocene or possibly early Pliocene.

In 1930 in a report for the Humble Oil and Refining Company the writer traced this horizon in the subsurface from Terry Field in Orange County, south of Burkville to Calhoun County. The name *Potamides matsoni* zone was suggested for this horizon as found in the subsurface. This zone has been found to be 400 feet or more in thickness and can be traced consistently in the subsurface. The zone is essentially a clay in East Texas with increasing amounts of sand toward the west. As far west as Brazoria County the section becomes quite sandy and more fossiliferous, including gastropods, pelecypods, ostracods, and foraminifers. Beach conditions alternate with brackish water or lagoonal conditions. In some areas the fossils are abundant, in others, the fossils are found in thin lenses and the key fossil, *Potamides matsoni*, is rather scarce, occurring intermittently throughout the section.

Since Veatch and others have recognized the Burkville beds as a mappable unit and have described sections and the fauna thereof, it is no doubt worthy of the rank of a formation. However, there is some question as to the advisability of introducing a new formation for the present without further work in the field. For the subsurface at least, the faunal zone is desirable at this time and the key fossil, *Potamides matsoni*, is used to designate the zone. As mentioned previously the megascopic fauna has been published. The microscopic fauna is to be published later.

ALVA C. ELLISOR

HOUSTON, TEXAS
February 6, 1936

[2] A. C. Veatch, "Report of the Geography and Geology of the Sabine River" (Louisiana Geol. Survey, 1902), p. 136.

[3] Dumble, "The Geology of East Texas," *Univ. Texas. Bull. 1869* (1918), p. 223.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 20, NO. 4 (APRIL, 1936), PP. 496-508

REVIEWS AND NEW PUBLICATIONS

* Subjects indicated by asterisk are in the Association library and available to members and associates. A list of technical periodicals available for loan to members and associates was published in the *Bulletin*, Vol. 18, No. 9 (September, 1934), pp. 1215–17.

---

* *Historical Geology of the Antillean-Caribbean Region or the Lands Bordering the Gulf of Mexico and the Caribbean Sea.* By CHARLES SCHUCHERT. 811 pages, 16 paleogeographic maps, 107 text figures, geologic and geographic maps, et cetera. New York, John Wiley and Sons (1935). Price $10.00.

Professor Schuchert has won the gratitude of all geologists by a work which is indispensable to all whose work or interest have to do with this vast province. It is especially to be commended to American geologists as a class because few of us are entirely guiltless of the besetting sin of provincialism. We need more regional treatises like this one and we also need to make more and better use of them as they become available.

The work is more than a compilation based on nearly all available literature. It attempts also the interpretation of the paleogeography, historical geology, and tectonics. Fairly complete bibliographies of the literature likewise are included in it.

It is unfortunate that most of the geologic work yet done in the Antillean-Caribbean province has been in the lowlands; the most interesting and important geology, as in many regions, lies in the mountains. Some day the petroleum industry will learn this to be the fact. Furthermore, no one without the actual experience ever appreciates the difficulties in tropical geology, climatically, entomologically, and botanically in their effects upon both rocks and humanity. For example, there is the usual uncertainty whether a scarp is caused by erosion, by structure, or the precise nature of the structure, the days spent in vain in searching for determinative fossils or unaltered rocks, the common uncertainties concerning true stratigraphic relationships or formation thicknesses in either lowland jungles or the rain-forests of mountain slopes. As a consequence, much of what is written is surmise and not demonstration of fact. For errors made by other writers, Dr. Schuchert is in no wise responsible. His has been a very difficult task, very creditably accomplished.

Obviously, it is impossible to give the conventional type of review of a volume of so great a scope. This review is unduly long but is restricted mainly to a few corrections and some more lengthy comments. It is submitted in the hope that it may serve as a supplement to Dr. Schuchert's work. Of the Antilles and northern South America the reviewer can say nothing because he had no first-hand knowledge of them; therefore, his remarks apply mainly to Mexico and northern Central America.

A late paper by Valentine[1] demonstrates that the basal granite at Cananea in northeastern Sonora is intrusive into the Pennsylvanian. It is noteworthy that at the present time we know no absolutely certain pre-Cambrian exposure between the United States-Mexican border and the equator, although, perhaps, it is more probable that some of the basement complex of the Guianian shield is pre-Cambrian.

[1] Wilbur G. Valentine, "Geology of the Cananea Mountains of Sonora, Mexico," *Bull. Geol. Soc. America*, Vol. 47 (1936), pp. 53–86.

The author (page 30) considers that two "orogenic" and one "epeirogenic" diastrophic epochs have been prevalent in the province. It is difficult to perceive how any valid distinction can be made. The Laramide "orogeny" is certainly less intense south of the Rocky Mountains properly delimited and passes into an "epeirogeny" in the Gulf of Mexico Coastal Plain. Similarly, the late Miocene-to-Pleistocene "epeirogeny" is really the great "orogeny" which has made all the existing mountain ranges, but, like the Laramide, is an "epeirogeny" in the Gulf Coastal Plain. It is not at all certain yet that his late Paleozoic "orogeny," by which we assume he means the Ouachitan (really Pennsylvanian and not Permian in its greatest intensity),[2] was characterized by intense mountain-making movements except in the narrow belt extending from Arkansas to the Rio Grande. In brief, should we not inquire whether "epeirogeny" is not complementary to "orogeny" and whether both do not have the same causes?

It should be noted (pages 32 and 33) that no really definite evidence of Appalachian mountain making is known in Mexico, Colombia, or Venezuela. Cuba illustrates the point, its Middle and Upper Jurassic rocks being highly deformed and even metamorphosed before the Lower Cretaceous. Similarly, Trechman has shown that so-called "pre-Cambrian" metamorphics of northern Trinidad have Cretaceous fossils. Where rocks are not surely dated, diastrophic correlations are usually mere guesses.

Whether Nevadian diastrophism (page 33) occurred in Mexico can not be stated categorically. Schuchert places this diastrophism near the end of the Jurassic; in reality, as proved by J. P. Smith, F. M. Anderson, and others, it came near the end of the Middle Jurassic.[3] In all northeastern Mexico there is no Jurassic known earlier than Upper and in northwestern Mexico the only known Jurassic is Lower (Lias of Sonora). The pre-Cretaceous diastrophism of northeastern Sonora, and likewise of northeastern Mexico, previous to Upper Jurassic, may be proved Nevadian. The second sentence on page 34 is apparently an error due to an oversight; it is possible that Mexico instead of Texas is meant. Overthrusting (page 35) or even intense folding "very late in the Cretaceous or early in the Eocene" has not been positively proved anywhere in Mexico. The intrusions and metamorphism of Cretaceous, Jurassic, et cetera, in Oaxaca and Guerrero may be proved late Cenozoic. The northeast Mexican Cordillera are one-cycle mountains now in maturity (the age of which will be apparent to any physiographer); furthermore, on their lower eastern flanks strata certainly as high as Oligocene are folded with the Cretaceous rocks. Conglomerates of anything like requisite amount which should have been produced by any strong Laramide "orogeny" are conspicuously lacking in eastern Mexico. Nor has the reviewer found any definite evidence of Laramide "orogeny" in Central America.

Shuchert's exposition of diastrophic causation (pages 45 to 47) is perhaps as able a one as it is now possible to make, provided one accepts the basal premises. It is most suggestive and merits much thoughtful consideration.

There should be added, on page 137, the occurrence of marine Permian in La Presa or Peregrina Cañon, northeastern Mexico. James B. Dorr and the reviewer collected *Fusilina* from the "mortar beds" intercalated in the black shales. Dr. Dunbar considers these probably to be *Parafusilina*. Very note-

[2] The author meant the Ouachita Appalachian orogenies of late Paleozoic time.

[3] Schuchert says after Kimmeridge time in California.

worthy is the fact that this marine Permian occurs only 85 miles from the shore of the Gulf of Mexico.

The fossils from Chinameca salt anticline in southern Veracruz, mentioned on page 144 as indicating Upper Triassic, are really Kimmeridgian Upper Jurassic. The reviewer had the rock quarried and the abundant fauna was identified by Dr. Carl Burckhardt. In a conference with the late Dr. J. P. Smith, the latter admitted his error in age determination, stating that he had forgotten the recurrence of the *Halobia* and *Daonella* in the Upper Jurassic, Burckhardt having demonstrated this previously.

The author has misunderstood the reviewer in the statements attributed to the latter on page 183. There seem to be two different gypsum horizons in the northeastern Mexican Cordillera, unless, perchance, the very complicated thrusting has played strange tricks. The Trinity (Glen Rose) gypsum has been traced from the Monterrey-Saltillo railroad line northward through Coahuila and eastern Chihuahua and as far northeast as Arkansas. In the Nuevo Leon-Tamaulipas border area, in the very complicated thrusts in the higher anticlines, from the southern end of the long and mighty El Novillo anticline west of Cuidad Victoria to the northern end of that uplift near Las Virgenes Ranch, an apparently older gypsum underlies marine Kimmeridge. It was found underlying the marine Kimmeridge (Upper Jurassic) as far west as the very complicated anticlinal valley of Las Antonias (at the west base of Cerro Pena Nevada, the highest peak in northeastern Mexico). This lower gypsum may be in the Red-beds section and may be of the same age as the salt, anhydrite, and potash salts of the Isthmus of Tehuantepec salt anticlines. In the Chinameca (Tonalapa) salt anticline of the Isthmus the saline residues interbedded with Red-beds underlie marine Kimmeridge and are older unless there is an overthrust between the two.

The section of the El Novillo uplift is as follows in descending order.

1. Uppermost Jurassic and Lower Cretaceous, mainly limestone
2. Angular unconformity, folding, and erosion (Nevadian "orogeny"?)
3. Highly deformed Red-beds; no fossils could be found
4. Angular unconformity, folding, and erosion
5. Highly deformed marine Permian black shales and mortar beds
6. Keokuk Mississippian sandstones and conglomerates
7. Basement complex

The relationships between 5, 6, and 7 can not be seen in upper LaPresa (Peregrina) Cañon. The position of the Red-beds (3) shows that their possible age range is between the first half of the Permian below and the middle Upper Jurassic above.

Serious illness of his associate prevented the reviewer from carrying his investigations north-northwestward in the great El Novillo uplift. Wallace Gordon found Basement complex and probable Paleozoic in Caballero Cañon, next north of La Presa Cañon. Frank L. Nason[4] found on the west of Santa Engracia thick sections of black shales with coal, underlain by thick sandstones resting on serpentine (?) (Basement complex (?)). (Six different serpentine minerals are found in the complex in El Novillo Cañon, farther south-southwest in the same uplift.) On the Cañon de San Bartolo, above Las Virgenes Ranch, Cummins determined that the coal was probably Upper Jurassic. Burckhardt found Upper Jurassic coal farther northwest, near Aramberri.

[4] "Some Phenomena of the Folding of Rock Strata," *Economic Geology*, Vol. 4 (1909), pp. 421–37.

The thorough study of the El Novillo uplift north of La Presa Cañon, during the dry season of April–May is of the very greatest importance; Nason's sections of the lower sediments appear inordinately thick, although they may be repeated by the thrusting and folding known to be prevalent. It is possible that the sandstones and black slates found by Nason belong to the Portlandian (uppermost Jurassic); Burckhardt found very similar thick Portland sediments farther northwest. The area is readily accessible, being situated a short distance west of Santa Engracia on the Laredo-Mexico City highway and likewise is reached readily from Ciudad Victoria by way of La Presa Cañon. The investigation should begin in Caballero Cañon and extend north-northwestward.

On the same page 183 (also page 193) Schuchert considers that the folding and thrusting of the northeastern Mexican Cordillera are Laramide, a view not shared by the reviewer, who agrees with Tatum.

The phyllites and marbles near Chivela on the Tehuantepec railway, in the vicinity of the continental divide, contain middle-to-late Paleozoic fossils.[5] (Pages 183–186 and 380–381.)

The age of the metamorphism is unknown. The reviewer's paper, already cited, shows that northward overthrusting involves certainly rocks as young as the Red-beds. Overthrusting may continue farther north at the junction of the Red-beds with marine mid-Mesozoic. Still farther north on the Isthmus the Tertiary, including the Pliocene, is moderately folded, the "salt anticlines" being intruded along anticlinal axes. Therefore, it is possible that the metamorphic belt extending from Guerrero, through southern Oaxaca into southwestern Chiapas, thence to Guatemala and Honduras, may have been metamorphosed in a time as late as Upper Cenozoic. In Oaxaca and Guerrero some of the metamorphism is known to be post-Cretaceous, although not all the metamorphism may be so late. De Böckh, Richardson, Bourchier, and Tait[6] found "wonderful nappes all moved to the north" in northern Guatemala. Henry Hawley and Roy E. Dickerson have told the reviewer that about 40 miles inland from the head of the Gulf of Honduras there is an overthrust front about a mile high of Pennsylvanian limestone thrust northward over Nummulitic Eocene; the Pennsylvanian fossils were determined by the late Dr. J. P. Smith. These facts controvert three of Schuchert's impressions and appear to show that: (1) apparently much of what he refers to the Permian is Pennsylvanian[7]; (2) northward overthrusts are to be expected from the Gulf of Honduras to west-northwest of the Isthmus of Tehuantepec, and (3) the age of this particular "orogeny" is neither Appalachian nor Laramide but sometime during the Cenozoic.

The following is quoted from *The Structure of Asia*[8] because it may be overlooked by geologists.

> The red and green rocks (Giron of Colombia) are much like the Todos Santos beds of Guatemala. There, too, the latest marine Paleozoics are of Upper Carboniferous age; then folding occurred, and the red and green Todos Santos beds were deposited.

[5] C. L. Baker, "Geological Cross-Section of Isthmus of Tehuantepec," *Pan-Amer. Geol.*, Vol. 53 (1930), pp. 161–74.

[6] *The Structure of Asia*, p. 161. Methuen and Company, London (1929).

[7] Schuchert is certain that most of the "Pennsylvanian" of Central America is Permian, as is shown by some of the fossils collected by Sapper; none of these fossils is positively Pennsylvanian. There may be Upper Carboniferous present, but as yet this is not proved.

[8] *Ibid.*, p. 164.

The transgression of the Cretaceous seems to have been later in Guatemala then in Colombia as we could not find anything older than Middle Cretaceous. [Fossils found by the reviewer in the Chinameca (Tonalapa) salt intrusion, northern Isthmus of Tehuantepec, were determined by Böse and Burckhardt to be Valanginian Lower Cretaceous.] The age of the red and green series cannot be determined exactly, but these beds lie between the Upper Carboniferous and the Cretaceous and may represent Permian, Triassic, and Jurassic in Colombia, and the same formations with Lower Cretaceous in Guatemala. [Burckhardt determined Lower Cretaceous fossils from the upper Todos Santos.] The salt-plugs in the neighbourhood of Bogota, which penetrate the marine Cretaceous beds, must be connected with these older beds. It is interesting that the Todos Santos beds of Guatemala contain gypsum near San Mateo Ixtatan and both gypsum and salt near Quetzal. We must here note that part of the Santa Rosa beds in Guatemala are equivalent to the Todos Santos, and appear in tectonic windows and pinched-in wedges from below overthrust Carboniferous.

The age, or ages, of the Red-beds of Mexico, Central America, and northwestern South America is problematic. They extend as far south as Argentina; at least the lower part of them in Brazil is apparently Triassic. Are they all of the same series? In stratigraphic position they recall the old "Jura-Trias" of our West, being intercalated, considered as a whole, between marine Pennsylvanian and marine Upper Jurassic-Lower Cretaceous. The reviewer spent much time searching for fossils in them in both Central America and Mexico but never found a single scrap. They are cut by quartz veins and contain usually considerable arkose and conglomerate.

Really, we shall never know much of the fundamental geology of Central America until the whole mountain belt between the southwest Oaxaca coast and the Gulf of Honduras has been investigated much more carefully. A more promising field for research would be difficult to find, but climate is unpropitious and so are the jungle and noxious insects. There is a grossly misnamed "dry season" beginning more or less with January; at least the winter is best for field work. The Pacific slope of Chiapas and eastern Oaxaca is almost a desert, almost unendurably hot in the lower altitudes, at least in the dry, later winter and early spring.

The age of the folding of older strata can not be determined until we know the age of the Todos Santos, which may be proved of different ages in different localities in northern Central America.

J. M. Muir writes that Dr. Schuchert has quoted him as saying that El Abra limestone is equivalent to the Tamasopo; in reality, Muir has taken particular care to show that the two are not the same.

Schuchert devotes considerable space to the biogeography of recent plants and animals. Unfortunately, this leads to no definite results.

Nor are the structural, stratigraphic, and physiographic geologists any better off. If it be true that no period in this region is free from orogenic disturbances, the temptation for mere conjectures must be avoided constantly. There is always the tendency to correlate and, unfortunately, to correlate with a few theoretical so-called "major" orogenies. There are those, for instance, who are determined to place any and all earth movements from the Jurassic to the present into the Laramide and any and all movements from Mississippian to Triassic into the Variscan or Appalachian. Certainly, most diastrophisms need to be much more accurately dated.

When we consider the tectonics we find that the author has trimmed much off both ends of the picture.[9] Though absolute boundaries do not exist, there appears to be a near approach to a northwest end of the Antillean-Carib-

[9] Obviously, no discredit to Schuchert is here implied; it chances that the tectonic province appears to be considerably greater than the area he treats.

bean province near Cape Mendocino, California. A southeast end can be assumed at Cape São Roque, Brazil, and St. Paul Rock in mid-Atlantic. Its northeast limit extends from the mid-Atlantic ridge through the shear zone between the southwesternmost Appalachians and easternmost Ouachitas. Its southwest extremity is the scarp which bounds, Pacificward, the shore-neighboring deeps extending from the mouth of the Gulf of California to the Bay of Panama. The Guyana Shield and Amazon Basin are in the province; so are the California Coast Ranges, including those now submerged beneath the Pacific.

This province is markedly straight and fairly uniform in width. We think, in Texas, where we have determined pre-Cambrian strikes, that it has existed from the pre-Cambrian. Two long linear zones of structure paralleling its course are known in the United States. One extends from the vicinity of Havana, Cuba, through the Mississippi delta (the situation of which it determines), through the Anadarko basin and the Uinta basin to the southern Wasatch Mountains. The other begins in the Sigsbee deep of the Gulf of Mexico, going through the Nueces River syncline and the zone separating north and south Trans-Pecos Texas, forming the southwest margin of the Colorado Plateau and it may end in Lassen County, northern California.

The tectonics are compressional with much shear and drag, a number of geanticlines and geosynclines, and many intrusive magma masses and their extrusive products. Perhaps it is characteristic of narrow regions between major continental masses. At any rate, we find a similar belt in the Old World all the way from New Zealand to Spain and Morocco. Add to these belts the remainder of the Pacific margin and we have in the three all the more intense mountain making since the Jurassic.

It is notable that the Appalachians meet the intercontinental structure at a right angle; so also does southeastern Brazil, so far as the reviewer has been able to determine, while the northern Andes are dragged into it, likewise the Uinta Mountains, the Colorado Rockies and the central and eastern Wyoming Rockies.

The reason why we think that our province is to be called the American Tethys is that most of the sedimentation in the New World since the beginning of the Jurassic has been in it. We must remember also the geosynclinal sedimentation of the later Paleozoic in the northeastern Mexican Gulf borderland. As Ulrich aptly remarks, "After the Ouachitan folding came the Gulf of Mexico."

Is major sedimentation an effect or a cause of orogeny? Or is it both? One may take his choice as yet. Also, he is at liberty to conceive the cause as a movement of one continent with respect to the other, or a movement of both, either parallel with the major northwest-southeast axis or at a right angle to the major trend.

However, perhaps the great continental masses may be compared with immense salt domes. There appears to be a mechanism which perpetuates the continents. In most places, the fault-foundered southeast Brazil coast being perhaps the most marked exception, the nuclear older rocks are rimmed coastward largely by later sediments from the nuclei. Therefore, the continents appear to grow in area; if so, their nuclei must rise in order to supply sediments. Chamberlin told us 30 years ago that heavier matter is dissolved from the land and lighter accumulates thereupon or around the edges. If the continents are lighter, underflow toward them of mobile material may raise them, surface transportation may widen them, and stresses be generated

toward the periphera. If so, we may be wrong in going to ocean basins for deformative forces affecting surficial rocks. In this case of the entire Antillean-Caribbean zone it may be enlargement of the two continents which has squeezed, dragged, and thrust the intermediate region.

The Caribbees perhaps are to be explained as a volcanic arc in a pressure fracture belt with two predominant times of volcanism. The first pile of fragmental submarine volcanics subsided under gravitative adjustments caused by their own weight and by marginward movement of the incompetent materials down the slope. Later, a renewal of extrusion may have built up the present volcanic arc with rise of magma bringing the northeastern part out of the water and tilting it toward the Atlantic. Subsidence of the later volcanics appears to be taking place due to the settling and outward creeping.[10]

We prefer Woodring's view of Greater Antillean tectonics. The relief pattern more resembles one formed by compression and the Bahama platform may be a northeastward thrust sheet. It may be noted that horsts and grabens need not be produced by "tensional" faulting or movements.

It was Suess's main thesis that movement of the earth's surface is downward, caused by volume contraction, tantamount to compression. We are not denying this but suggest a modification, which is that this downward movement may be differential. In fact, it must be from the known results.

The reviewer has at present the impression that we confine ourselves to far too limited areas in attempting to explain diastrophism. Perhaps one of the reasons why so many European geologists favor Wegenerian drift is that they are coming to realize that Alpine orogeny is so intense in such a narrow *intercontinental* belt that stresses must have been transmitted through competent plates hundreds of miles in breadth, producing something in between which resembles what takes place when two large ice floes drift together.

Schuchert's view (top of page 19) is

> What we see is the intermittent dynamic compressive work of the subsiding and widening basins, namely, the Caribbean Sea and the Pacific and the Atlantic oceans to which was finally added the foundering of the once shallow basin of the Gulf of Mexico.

We most certainly agree that the dynamics are compressional. It is noteworthy, however, that Schuchert adds little or nothing to the sum total of either land or sea throughout geologic time. He founders the Llanorian, Antillean, and Parian geanticlines and brings up the present lands in compensation. There is perhaps much to commend this because a study of the leading geosynclines of the earth, past and present, seem to indicate the working of a law which may be expressed as the migration of geosynclines in time and space. The conversion of a geosyncline into a compressed mountain range is accompanied and followed by the development of sedimentary basins on one or the other or both flanks. The Ouachita province may be cited as an example. Its mountain making out of a preceding geosyncline was followed by the Pennsylvanian-Permian-Upper Triassic basin on the northwest and then, after the Triassic, by the present Gulf geosyncline on the opposite flank. The prime fact which stands out in the Antillean-Caribbean belt is its persistent instability and the shifting of the places of erosion and deposition.

Should the foregoing conjectures not be proved workable there is still possible recourse to mass movement of continents. The form of the Caribbee

[10] C. L. Baker, "The Formation of Indo-Pacific Coral Reefs and Atolls," *Pan-Amer. Geol.*, Vol. 60 (1933), pp. 15–24.

arc and the northeasternmost offshoots of the Andes suggest a northwestward movement of South America during the Cenozoic. Also, there is some possibility that the Brazilian shield, moving westward, has forced up the main Andes and produced the foredeeps close to the Pacific shore. Likewise, there is suggestion of drag along the North American continental junction with the Antillean-Caribbean zone.

Finally, we come to the "Asthenosphere" hypothesis of Daly and Willis, favored by Schuchert (see pages 41–47 of the work now reviewed). This is still new and strange and has not been thought out by the reviewer. He dares to comment upon it only because of some probable facts of Alpine orogeny. From the Atlas to the eastern Himalayas the fold-thrust mountains are intercontinental, not marginal to continents; the Alps, Carpathians, and Caucasus are especially so and likewise very complicated. In the New World the Ouachitas are likewise intercontinental or intracontinental, at least according to Schuchert. Something else is equally pertinent. So many geologists working these last 75 years in the Alps are not all likely to be wrong. In order to produce the great amount of compression, there must be "creep" of a large area or areas toward the weaker zone of yielding. In total amount, however, this is very far short of that postulated in Wegenerian drift.

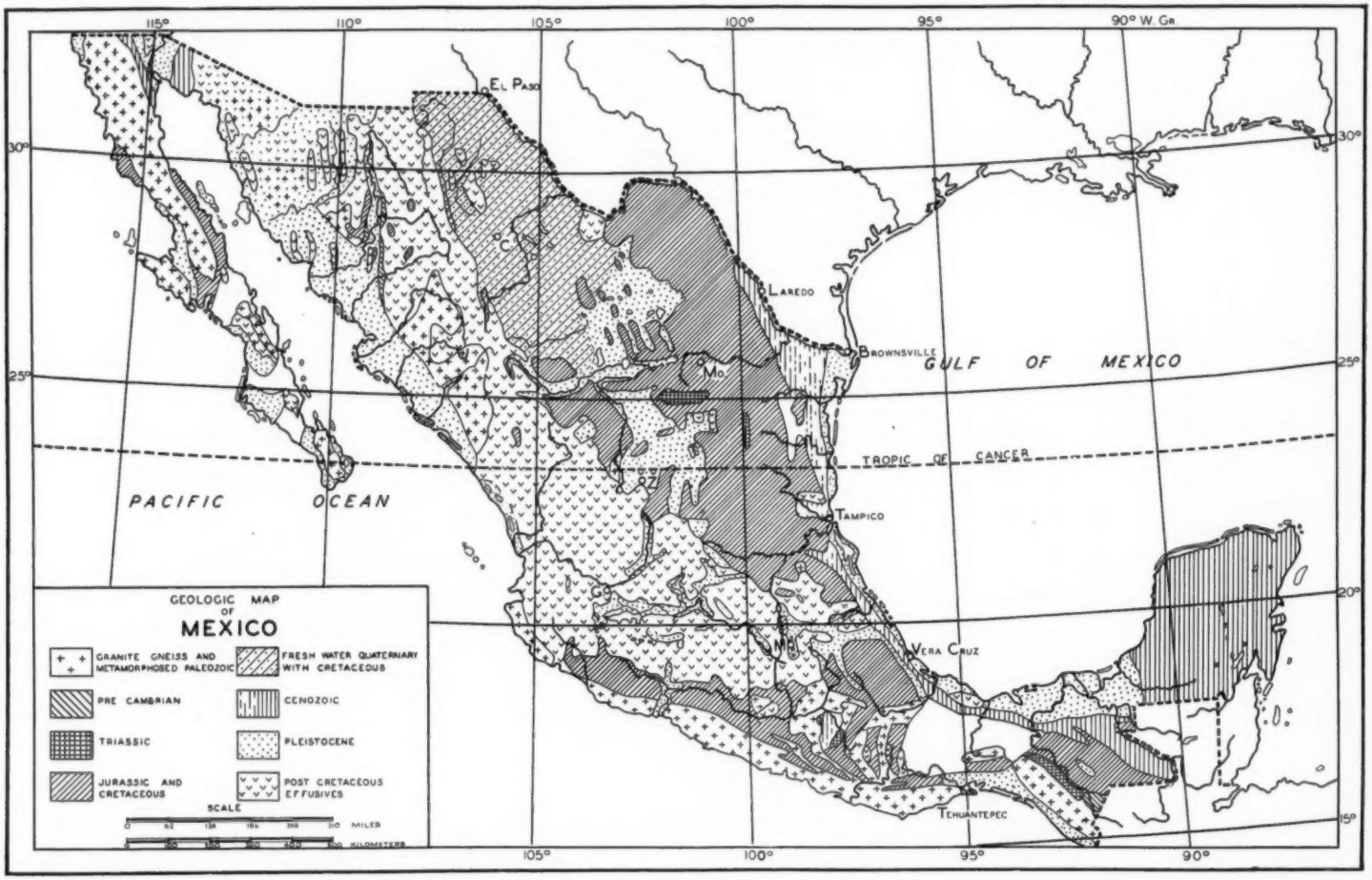
If "lighter magmatic differentiates are flowing toward and beneath the continents" in the top of the vitreous asthenosphere they should encounter enormous friction. It is indeed a long journey from the ocean basins to the Alps, Carpathians, and Caucasus. Would not there be a tendency to lift or "float" the superincumbent shell? Would it not be easier than to flow so great distances? Broad and high Tibet borders on the north still higher and southward-overthrust Himalayas. North of Tibet are the great depressions, of equivalent area, of the Tarim, Tsaidam, and southwest Mongolia, situated in the very heart of the greatest continent. South of the Himalaya is the Indo-Gangetic depression with the upland of peninsular India between it and the Indian Ocean. We merely inquire, for purpose of testing, whether the hypothesis of asthenosphere flowage can meet these rather complicated requirements.

Considering specifically Europe, Africa, and the Alpine orogeny and Mediterranean depression between the two continents and the similar relationships in the New World with respect to the Antillean-Caribbean "Mediterranean," we propose tentatively the following suggestion. The continentward flowage of lighter material in the upper asthenosphere may float up "positive" areas, erosion of and transportation from which may fill up adjoining geosynclinal depressions. It may also drag the surface along toward the continental interior. Drag may be produced at least in part by rotation of the spinning earth. Or, should the surface be floated up out of balance with the spheroid of rotation, adjustment creep may be a consequence. One thing seems to be growing visible in the general fog, namely, that belts of yielding (or weakness) are primitive or at least pre-Cambrian.

Fundamentally and in the final analysis we need to know the primitive shape of the earth—a requirement which we all have disregarded and concerning which no attempt has been made since Lowthian Green proposed the tetrahedral earth.

CHARLES LAURENCE BAKER

COLLEGE STATION, TEXAS
January 17, 1936



Geologic map of Mexico, by Sorre, redrawn from the Geographical Atlas of the Mexican Republic. From *Geógraphie Universelle* (1928), by permission of Librairie Armand Colin, Paris. Modified from Charles Schuchert, *Historical Geology of the Antillean-Caribbean Region* (John Wiley and Sons, New York, 1935), Fig. 18, p. 117. White areas indicate unmapped geology. *C.* = Chihuahua. *Mo.* = Monterrey. *Z.* = Zacatecas. *G.* = Guadalajara. *M.* = Mexico City.

**Tertiary Faunas. Vol. 1. The Composition of Tertiary Faunas.* By A. MORLEY DAVIES. "A textbook for oilfield paleontologists and students of geology." 406 pp., 565 figs. 5.5×8.75. Cloth. Thomas Murby and Company, 1 Fleet Lane, London, E. C. 4. Price, £22, 6 s., net.

A recent publication by A. Morley Davies entitled *Tertiary Faunas, Vol. 1*, is a very good introductory textbook for systematic paleontology. As stated in his preface Dr. Davies does not claim to be an authority in the matter of nomenclature. He states:

> I have tried to place before my readers the alternative generic names they will find both in past literature and, so far as it can be foreseen, in that of the immediate future; and I have had in each case to choose one name as the most correct and enclose the rest within square brackets. In these concentration-camps are herded together many that will suffer the death-penalty (absolute synonyms), some doomed to banishment (homonyms), some that may be set free and acclaimed as the long-lost heir, and yet others that may be allowed to live as poor relations (sub-genera). I have tried not to be too arbitrary a dictator in my choice of victims, though I am sure to be criticized. Where recent rectifications in nomenclature seem likely to be generally adopted I have accepted them, but where there is a conflict of opinion as to which of several forgotten names should replace a familiar one, I have retained the latter.

The first chapter deals with Tertiary *Foraminifera*. In the limited space of 60 pages the subject can be treated only in a very introductory manner. After a brief introduction which includes a tabulation of the differences between the megalospheric and the microspheric forms of a species, which is very helpful, the author gives a comparison of three classifications, Brady's (1884), Cushman's (1933), and Galloway's (1933), and states that in this text he uses Brady's classification as the others are "still tentative and present a forbidding complexity to the student." The author has four pages of glossary of principle technical terms applied to *Foraminifera*. This in particular is very valuable to the micropaleontologist.

The second chapter deals with Tertiary *Echinoidea* and is an excellent piece of work. The plates consist of outline drawings with reference letters by means of which the figures are clearly explained. A glossary of technical terms and a select bibliography complete the chapter.

In Chapter III, Tertiary *Lamellibranchia* are dealt with in the same fashion. The author's descriptions and definitions of the various parts of the pelecypod are the clearest available. The illustrations are outline drawings but are so arranged as to show the comparison of the diagnostic characteristics of the different genera.

The *Gastropoda* are treated in Chapter IV, including clear explanations and definitions of characteristics of the phylum. Each family is briefly discussed, and the characteristics of the sub-families given. Under each genus the geologic range as well as the geographic range is given.

All other Tertiary invertebrata are discussed in Chapter V. A very brief outline of the vertebrata is given in Chapter VI.

This book is a very valuable textbook and reference book for the systematic paleontologist. It is the most complete compilation to date of definitions, technical terms, and geologic and geographic range of genera. The descriptions are brief but clear and concise. Abbreviations are freely used which make it possible to give in a short space many data such as the geographic and geologic ranges of the genera. Both a systematic and a general index complete the book.

ALVA C. ELLISOR

HOUSTON, TEXAS
February 11, 1936

RECENT PUBLICATIONS

AFRICA

*"Southeast Africa Oil Possibilities To Be Tested by Well Under Way," by L. G. Putnam. *Oil Weekly* (March 9, 1936), pp. 46–47; 1 map.

CALIFORNIA

*"Geology of the El Segundo Oil Field," by E. Baden Powell. *Petrol. World* (Los Angeles, California), Vol. 33, No. 2 (February, 1936), pp. 15–17; map.

CANADA

*"A Preliminary Contribution to the Floras of the Whitemud and Ravenscrag Formations," by E. W. Berry. *Canada Geol. Survey Mem. 182* (Ottawa, 1935). 107 pp., 20 pls. Contribution to paleobotany of late Cretaceous-early Tertiary deposits of southern Saskatchewan. 6.5×9.75 inches. Paper. Price, $0.25.

COLORADO

**Resume: Rocky Mountain Oil and Gas Operations for 1935–1936.* Edited by C. E. Shoenfelt. Published by Petroleum Information, Inc., Continental Oil Building, Denver, Colorado. 105 multigraphed pp. 30 geologic maps; folded insert geologic correlation chart. Annual summary. 8.5×10.75 inches. Paper.

ENGLAND

*"Drilling Campaign Authorized in Britain," anon. *World Petrol.* (New York), Vol. 7, No. 1 (January, 1936), pp. 20–21; 2 figs. "Granting of permits covering twelve separate areas marks beginning of systematic exploration to determine existence of oil deposits of commercial value."

GENERAL

**The Oil Weekly* (Houston, Texas), Vol. 80, No. 7 (January 27, 1936). 210 pp. Annual year book number.

**The National Petroleum News* (Cleveland, Ohio), Vol. 28, No. 6 (February 5, 1936). 512 pp. Special illustrated number featuring the oil industry's contribution to human progress.

**The Oil and Gas Journal* (Tulsa, Oklahoma), Vol. 34, No. 37 (January 30, 1936). 200 pp. Annual review number.

*"Controlled Directional Well-Drilling and Surveying Practice," by James D. Hughes. *Petrol. Engineer* (Dallas, Texas), Vols. 6–7 (July, August, September, November, December, 1935, and January and February 1936). 25 pp., 48 figs.

*"La Géophysique en Gulf Coast" (Geophysics in the Gulf Coast), by P. Charrin. *Revue Pètrolifere* (Paris), No. 671 (February 22, 1936), pp. 321–24. Includes 4 tables listing fields discovered in Texas and Louisiana, with and without the aid of geophysics.

*"Cyclic and Non-Cyclic Aspects of Erosion," by Nevin M. Fenneman. *Bull. Geol. Soc. America*, Vol. 47, No. 2 (February 29, 1936), pp. 173–86. Address of retiring president of the Geological Society of America.

*"Geological Education," by Charles K. Swartz. *Ibid.*, pp. 187–96. Address of retiring president of the Paleontological Society.

*"Geology, Chemistry and Petroleum Engineering Play Important Parts in Drilling Mud Control," by M. T. Halbouty. *Oil Weekly* (March 9, 1936), pp. 19–20; 1 fig. First of a series on drilling muds.

**General Index* (of *Economic Geology* and the *Bulletin of the Society of Economic Geologists*), Vols. 21–30 (1926–1935). 135 pp. Obtainable at $2.00 each from W. S. Bayley, University of Illinois, Urbana, Illinois.

*"21,420 Wells Completed in 1935 Give the Industry 15,108 New Oil Wells," by James McIntyre. *Oil and Gas Jour.* (Tulsa), Vol. 34, No. 37 (January 30, 1936), pp. 43, 46. Gives statistics by states for 1934 and 1935, and the total number of completions, dry holes, gas, and oil wells for each of the past 10 years.

ILLINOIS

"Geology and Oil and Gas Possibilities of Parts of Marion and Clay Counties, with a Discussion of the Central Portion of the Illinois Basin," by J. M. Weller and A. H. Bell. *Illinois Geol. Survey* (Urbana) *Rept. Investigations 40* (1936). 54 pp., 10 figs. Price $.025.

KANSAS

*"Subsurface Studies in Northeastern Kansas," by John Ockerman. *Kansas Geol. Survey* (Lawrence) *Bull. 20* (1936). 78 pp., 13 pls., 4 figs. Mailing charge, $0.20.

*"The Geology of Johnson, Miami, and Wyandotte Counties, Kansas," by Norman D. Newell and John M. Jewett. *Ibid., Bull. 21* (1936). 205 pp., 23 pls., 2 figs. Mailing charge, $0.20.

"Contour Map Showing Topography of Pre-Cambrian Surface Underlying Eastern Two-Thirds of Kansas." *Kansas Geol. Survey Map 61* (1936). 8.75×12.5 inches. Scale, 1:1,500,000. Contour interval, 200 feet. Mailing charge, $0.05.

"Map Showing Geologic Structure of Southeastern Kansas Coal Fields and the Kansas Zinc-Lead District." *Ibid., Map 64* (1936). Prepared by *U. S. Geol. Survey* (Public Works Administration funds). 17.5×24 inches. Scale, 1:125,000. Mailing charge, $0.10.

"Preliminary Edition Geologic Map of Kansas, Northwestern Section." *Ibid., Map 65* (1936). 17.5×14.5 inches. Scale, 1:500,000. Mailing charge, $0.10.

"————, Southwestern Section." *Map 66* (1936). 18×12 inches. Scale, 1:500,000. Mailing charge, $0.10.

NEW MEXICO

*"Guadalupan Series: Its Span and Affinities," by Charles Keyes. *Pan-Amer. Geol.* (Des Moines, Iowa), Vol. 65, No. 1 (February, 1936), pp. 35–56; 2 figs., 2 photos.

OHIO

*"Sylvania Sandstone of Northwestern Ohio," by J. Ernest Carman. *Bull. Geol. Soc. America*, Vol. 47, pp. 253–66; 1 pl., 5 figs.

RUSSIA

*"Method of Estimating Underground Oil Reserves," by V. V. Bilibin. *Problems of Soviet Geology* (Moscow), Vol. 6, No. 1 (January, 1936) pp. 34–42. In Russian.

*"Note on the 'Miocene' of Afganistan," by O. S. Vialov. *Ibid.*, pp. 43–44. In Russian.

*"On the Triassic of the Kusnetsk Basin," by V. A. Khakhlov. *Ibid.*, pp. 45–48. In Russian.

*"Contributions to the Stratigraphy of the Upper Paleozoic of the Aktyubinsk and Orenburg Districts," by V. E. Ruzhentsov. *Ibid.*, pp. 49–58. In Russian.

*"U.S.S.R. Situation," by M. N. Jurin. *Oil Weekly* (March 9, 1936), pp. 36–37; map showing oil fields and supposed productive area.

SYRIA

*"Matériaux pour la stratigraphie du Nummulitique dans le Desért de Syrie" (Nummulitic Stratigraphy in the Syrian Desert), by Mme. de Cizancourt. *Bull. Soc. Geol. France* (Paris), Ser. 5, Vol. 4 (1934), pp. 737–58; 1 fig., 3 pls. Eocene-Oligocene paleontology.

UGANDA

*"A Short Record of Progress Relating to Some Investigations in the Field and Laboratory, and of Some Results Obtained Therefrom." *Geol. Survey Uganda Bull. 2* (Entebbe, 1935). 84 pp. Illus. 8.5×10.5 inches. Paper. The Govt. Printer, Entebbe, Uganda, Africa. Price, Shs. 5. Among other articles, contains "Gravity Measurements in East Africa," by E. C. Bullard (2 pp., 1 fig.), of which E. J. Wayland, director of the Survey, states: "It is an extremely valuable contribution to a controversy which arose some 15 years ago concerning certain views I set forth with regard to the nature and origin of African rift valleys. Its significance is more than academic, for it is not without bearing on the petroleum-winning possibilities of the Albertine depression." The bulletin also contains a "Short Lexicon of Uganda Stratigraphy" (6 pp.), a "Bibliography of the Geology of Uganda" (2 pp.), and a "Provisional Geological Map of Uganda" (scale, 1:2,000,000).

WYOMING

*"Permo-Pennsylvanian Section of the Hartville Area of Wyoming," by G. E. Condra and E. C. Reed. *Nebraska Geol. Survey* (Lincoln) *Paper 9* (1935). 46 pp., 16 figs., 1 chart.

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 20, NO. 4 (APRIL, 1936), PP. 509-511

THE ASSOCIATION ROUND TABLE

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The executive committee has approved for publication the names of the following candidates for membership in the Association. This does not constitute an election, but places the names before the membership at large. If any member has information bearing on the qualifications of these nominees, he should send it promptly to the Executive Committee, Box 1852, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each nominee.)

FOR ACTIVE MEMBERSHIP

Chester Lathrop Herold, Houston, Tex.
R. D. Reed, Roy R. Morse, Charles E. Weaver
Hubert Andrew Ireland, Oklahoma City, Okla.
R. S. Knappen, Irving Perrine, V. E. Monnett
Raymond Field Kravis, Tulsa, Okla.
William H. Elson, Ira H. Cram, Harold S. Thomas
Frank Ellis Marshall, Wichita, Kan.
Ward R. Vickery, Glen C. Woolley, Howard S. Bryant
Ronald Owen Swayze, San Marino, Calif.
C. M. Wagner, William S. W. Kew, Harold W. Hoots
George R. Watson, Pittsburgh, Pa.
K. C. Heald, R. W. Clark, E. A. Eckhardt

FOR ASSOCIATE MEMBERSHIP

Manuel Alvarez, Jr., Atzcapotzalco, Mexico, D. F.
Lester C. Uren, Bruce L. Clark, Ezequiel Ordoñez
Wilton W. Andrews, Caripito, Venezuela, S. A.
Charles C. Mason, Thomas R. Warrick, John W. Brice
Willis Kenley Clark, Houston, Tex.
M. T. Halbouty, Roy R. Morse, R. C. Brehm
George Henry Crowl, Ciudad Bolivar, Venezuela, S.A.
R. O. Rhoades, E. S. Bleecker, C. S. Corbett
Edward Charles Doell, Taft, Calif.
W. F. Barbat, George M. Cunningham, G. C. Gester
Leonard R. Duerfeldt, Lincoln, Nebr.
E. F. Schramm, Eugene C. Reed, A. L. Lugn
Herbert C. Fletcher, Norman, Okla.
G. E. Anderson, V. E. Monnett, C. E. Decker
S. C. Giesey, Midland, Tex.
F. H. Schouten, Georges Vorbe, V. G. Hill
Ardris Haig, Denver, Colo.
J. Harlan Johnson, W. A. Waldschmidt, F. M. Van Tuyl
Castle J. C. Harvey, Shawnee, Okla.
Jack M. Copass, Jess Vernon, John L. Ferguson
Maynard Hugh Jameson, Golden, Colo.
F. M. Van Tuyl, J. Harlan Johnson, W. A. Waldschmidt
John Janovy, Pampa, Tex.
Charles E. Decker, V. E. Monnett, R. W. Harris
Joseph Brady Kennedy, Jr., Shawnee, Okla.
Frederic A. Bush, W. H. Wynn, Jack M. Copass
Raymond Charles Lewis, Pampa, Tex.
W. B. Hoover, Gentry Kidd, A. L. Ackers
Gregg Fernando McReynolds, Houston, Tex.
Dave P. Carlton, J. E. La Rue, L. P. Teas
James C. Menefee, Caripito, Venezuela, S. A.
Charles C. Mason, Thomas R. Warrick, John W. Brice
Hubert Emil Menger, Houston, Tex.
M. T. Halbouty, F. L. Whitney, F. B. Plummer
Kenneth Robert Parsons, Ada, Okla.
L. Murray Neumann, D. C. Nufer, E. O. Markham
Sidney Schafer, Pasadena, Calif.
Ian Campbell, B. Gutenberg, John P. Buwalda

Aden Edmund Stiles, Caripito, Venezuela, S.A.
Roger H. Sherman, John W. Brice, G. Moses Knebel
Raymond M. Trowbridge, Holdenville, Okla.
Ira H. Cram, John M. Ware, H. S. McQueen
Pollok Austin Wallace, Shawnee, Okla.
Jack M. Copass, Dollie Radler Hall, Jess Vernon
Ray A. Walters, Golden, Colo.
J. Harlan Johnson, F. M. Van Tuyl, W. A. Waldschmidt

FOR TRANSFER TO ACTIVE MEMBERSHIP

Henry Clay Arnold, Tulsa, Okla.
Frederic A. Bush, D. R. Snow, Jess Vernon
Ludwig Wilhelm Blau, Houston, Tex.
J. E. LaRue, L. P. Teas, Dave P. Carlton
Edgar Daniel Cahill, Tulsa, Okla.
Richard T. Lyons, Joseph E. Morero, Richard B. Rutledge
Nathan C. Davies, Wellsville, N. Y.
John R. Reeves, Joseph H. Turner, H. Rogers Van Gilder
James R. Day, Monument, N. Mex.
A. R. Denison, J. F. Hosterman, W. D. Anderson
Carlton Gallaher Dinsmoor, Moran, Tex.
Worth W. McDonald, P. G. Russell, T. F. Petty
Alden Stuart Donnelly, Midland, Tex.
Prentice F. Brown, Willard F. Bailey, Ronald K. DeFord
Barney Feagin, Jr., Tulsa, Okla.
Frederic A. Bush, Bruce H. Harlton, Dollie Radler Hall
Richard E. Gile, Midland, Tex.
Fred H. Wilcox, Cary P. Butcher, R. L. Cannon
John Hamman, Jr., Houston, Tex.
Paul Weaver, C. A. Warner, Lon D. Cartwright, Jr.
Dan Ott Howard, Oklahoma City, Okla.
W. C. Kite, Norman Meland, Clyde M. Becker
Elizabeth Alice Isaacs, Wichita, Kan.
A. F. Morris, J. M. Nisbet, L. I. Yeager
Luis Emmett Kemnitzer, Pasadena, Calif.
Ian Campbell, B. Gutenberg, Louis N. Waterfall
John Haviland Maxson, Pasadena, Calif.
R. D. Reed, H. W. Hoots, Albert Gregersen
Francis Herbert McGowan, Houston, Tex.
Dave P. Carlton, J. E. LaRue, J. Brian Eby
Robert B. Mitchell, Tyler, Tex.
William J. Nolte, Wallace Ralston, George W. Pirtle
Lindsey George Morgan, Wichita, Kan.
Phil K. Cochran, Robert B. McNeely, Marvin Lee
Lewis L. Nettleton, Pittsburgh, Pa.
K. C. Heald, R. E. Somers, R. W. Clark
Hugh Williams O'Keeffe, Shawnee, Okla.
D. A. McGee, J. K. Knox, J. C. Finley
Howard C. Pyle, Los Angeles, Calif.
H. W. Hoots, E. B. Noble, Louis N. Waterfall
Hewlett Ausborn Russell, San Francisco, Calif.
J. M. Kirby, G. M. Cunningham, G. C. Gester
Vernon Clifford Scott, Oklahoma City, Okla.
R. F. Baker, J. N. Troxell, E. B. Branson
Richard Walker Simpson, Jr., Ada, Okla.
H. B. Fuqua, R. M. Whiteside, G. C. Siverson
John Teagle, San Antonio, Tex.
W. K. Esgen, L. T. Barrow, Wallace Pratt
Maurice Richard Teis, Ada, Okla.
D. A. McGee, J. C. Finley, J. K. Knox
Jerry Eli Upp, Wichita, Kan.
Robert L. Cassingham, V. H. Welch, Phil K. Cochran
Herman W. Weddle, Los Angeles, Calif.
William S. W. Kew, Herschel L. Driver, R. G. Reese
George Edward Woodward, Jr., Houston, Tex.
R. S. Powell, Alan Bruyere, Louis A. Scholl, Jr.

ASSOCIATION COMMITTEES

EXECUTIVE COMMITTEE

RALPH D. REED, *chairman*, Los Angeles, California
CHAS. H. ROW, *secretary*, San Antonio, Texas
A. I. LEVORSEN, Tulsa, Oklahoma
C. E. DOBBIN, Denver, Colorado
L. C. SNIDER, New York, N. Y.

GENERAL BUSINESS COMMITTEE

ARTHUR A. BAKER (1938)
R. F. BAKER (1937)
WILLIAM A. BAKER (1937)
ROY M. BARNES (1937)
ROBERT L. CANNON (1937)
C. G. CARLSON (1938)
IRA H. CRAM (1937)
THORNTON DAVIS (1937)
FRANK W. DEWOLF (1937)
C. E. DOBBIN (1937)
J. BRIAN EBY (1938)
H. B. FUQUA (1937)
L. W. HENRY (1937)
HAROLD W. HOOTS (1938)
JAMES W. KISLING, JR. (1937)
A. I. LEVORSEN (1937)
THEODORE A. LINK (1937)
GERALD C. MADDOX (1937)
J. J. MAUCINI (1938)
JAMES G. MONTGOMERY, JR. (1937)
KENNETH DALE OWEN (1937)
RALPH D. REED (1938)
CHAS. H. ROW (1937)
G. W. SCHNEIDER (1937)
GAYLE SCOTT (1936)
E. F. SHEA (1937)
L. C. SNIDER (1937)
CLARE J. STAFFORD (1937)
J. M. VETTER (1936)
LOUIS N. WATERFALL (1937)
GERALD H. WESTBY (1937)
NEIL H. WILLS (1937)

RESEARCH COMMITTEE

DONALD C. BARTON (1936), *chairman*, Humble Oil and Refining Company, Houston, Texas
HAROLD W. HOOTS (1936), *vice-chairman*, Union Oil Company, Los Angeles, California
M. G. CHENEY (1937), *vice-chairman*, Coleman, Texas

R. S. KNAPPEN (1936)
W. C. SPOONER (1936)
PARKER D. TRASK (1936)
ROBERT H. DOTT (1937)
K. C. HEALD (1937)
F. H. LAHEE (1937)
H. A. LEY (1937)
R. C. MOORE (1937)
F. B. PLUMMER (1937)
JOHN G. BARTRAM (1938)
C. E. DOBBIN (1938)
STANLEY C. HEROLD (1938)
THEODORE A. LINK (1938)
C. V. MILLIKAN (1938)
JOHN L. RICH (1938)
C. W. TOMLINSON (1938)

REPRESENTATIVE ON DIVISION OF GEOLOGY AND GEOGRAPHY NATIONAL RESEARCH COUNCIL

FREDERIC H. LAHEE (1937)

GEOLOGIC NAMES AND CORRELATIONS COMMITTEE

IRA H. CRAM, *chairman*, Pure Oil Company, Tulsa, Oklahoma

JOHN G. BARTRAM
M. G. CHENEY
ALEXANDER DEUSSEN
B. F. HAKE
G. D. HANNA
M. C. ISRAELSKY
A. I. LEVORSEN
C. L. MOODY
R. C. MOORE
ED. W. OWEN
J. R. REEVES
ALLEN C. TESTER
W. A. THOMAS

TRUSTEES OF REVOLVING PUBLICATION FUND

CHARLES H. ROW (1936)
RALPH D. REED (1937)

TRUSTEES OF RESEARCH FUND

ROBERT H. DOTT (1936)
G. C. GESTER (1937)

FINANCE COMMITTEE

JOSEPH E. POGUE (1936)
E. DEGOLYER (1937)
THOMAS S. HARRISON (1938)

COMMITTEE ON APPLICATIONS OF GEOLOGY

FRANK RINKER CLARK, *chairman*, Box 981, Tulsa, Oklahoma

WILLIAM H. ATKINSON
ARTHUR E. BRAINERD
HAL P. BYBEE
HERSCHEL H. COOPER
CAREY CRONEIS
H. B. HILL
EARL P. HINDES
MARVIN LEE
S. E. SLIPPER
H. S. MCQUEEN
E. K. SOPER
J. M. VETTER

CHARLES THOMAS LUPTON

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 20, NO. 4 (APRIL, 1936), PP. 513-515

Memorial

CHARLES T. LUPTON

Charles Thomas Lupton was born February 28, 1878, near Mount Pleasant, Ohio, and died of heart attack May 8, 1935, at his home, 617 Gilpin Street, Denver, Colorado. In his passing the geological profession and the oil and gas industry lost one of their notable men, and his family a kind, most thoughtful and far-seeing father and husband.

Mr. Lupton was educated in the district schools of Ohio, in Oberlin University, class of 1907, and the National University of Law, Washington, D. C., in 1915. He was admitted to the bar but never practiced law. He taught in the district schools before entering college. In 1907 he became a member of the United States Geological Survey and resigned, September 1, 1916, to engage in professional geology with the Cosden Oil Company of Tulsa, Oklahoma. On November 25, 1914, he married Addie White Bradshaw of Sedley, Virginia, who survives him. He is also survived by one daughter, Martha, now a student of Earlham College, and three sons, Charles T., Jr., Franz Russel, and Bradshaw Babb, familiarly called Jimmy. A brother, Russell, of Oakland, California, also survives him. Though reared a member of the Society of Friends, he became an active member of the First Plymouth Congregational Church of Denver, Colorado.

Mr. Lupton's work with the United States Geological Survey first took him to the Powder River coal field near Sheridan, Wyoming, as an assistant to R. W. Stone; next to Montana; and later to Utah, Washington, Idaho, and other states. The first favorable impressions gained of the Rocky Mountains caused him never to forsake that area for other geologic regions. His life's work was mainly in this one great region, where he applied his knowledge gained in the survey work, and the practical phases of oil geology, in a most efficient and business-like way.

His authorship of scientific geological papers and reports qualified him for membership in the Geological Society of America and in the American Association of Petroleum Geologists. He was a member of the following societies: the American Institute of Mining Engineers, the American Mining Congress, the American Association for Advancement of Science, the Geological Society of Washington, the Colorado Academy of Sciences, and the Colorado Historical Society.

In 1916 he moved to Casper, Wyoming, where he was manager for the Cosden oil interests, and on December 1 he moved to Denver, Colorado. In 1919, ex-Governor Franz of Oklahoma organized the Franz Oil Corporation and became affiliated with Mr. Lupton for the purpose of wild-catting the Cat Creek anticline in Montana. These pioneering efforts of Mr. Lupton were directly instrumental in opening the important Cat Creek oil field. The discovery in 1920 of this high-grade and prolific oil field gave Montana its first real petroleum resource and paved the way for intensive oil prospecting in that state. The opening of the Cat Creek oil field was ever a real source of personal satisfaction to Mr. Lupton, for a natural resource had been added to the wealth of the State, much work made for many, and fortunes for some.

Other oil and gas fields which he had a direct hand in opening are Frannie, Allen Lake, and South Oregon Basin.

Mr. Lupton always had much faith in the oil and gas possibilities of the state of Washington. Even to the day of his death he labored to bring in oil in that state. The small gas wells in the Rattlesnake Ridge are the result of his professional advice.

The best evidence of his ability as a geologist is that he applied geology practically, thereby accumulating a comfortable income for the Lupton family estate. Theories meant very little to him. Cold facts he used to advantage. His success was due to his own rugged Americanism.

His acute business instincts were ever present in his daily life, and won for himself and his family the security against old age for which all ambitious men strive. I once asked Charles how it happened he was so frugal, did his father or professors ever coach him to be thrifty? "No," he said, "but while teaching school I saved enough, I thought, to pay my way through Oberlin. When I graduated I had more money than when I entered college, which gave me confidence that I could win my way through life no matter what happened." This explains the quiet independence of the man and his ability to extend a helping hand to some of his fellow geologists while on the Survey, and also to others during the terrible depression of 1929 when so many sank into the syncline of despair.

To those of us who had known Charles for more than 25 years, and to some of shorter acquaintance, his calm, confident, and optimistic view of life, seasoned with a goodly vein of humor, were most appealing characteristics. His kind consideration and keen enjoyment of elderly as well as younger folks, endeared him to a host of true friends. Always he had a word to say to the children of his friends. He took particular pains to talk with elderly persons, who never failed to praise his thoughtfulness.

As I attended the services at the Congregational Church, I thought less of his national fame as a great geologist, who backed his judgment successfully in prospecting for oil—a hazardous business at best—and more of the strong clean character that won him the loving admiration and devotion of his family and of a wide circle of loyal friends. I thought less of the record of his scientific publications, which will remain forever in our libraries, and more of the constructive and pioneering work of the man honored by all who knew him intimately. They presented him in those moments a beautiful floral tribute. Oddly, each year of his 57 years was matched by some staunch friend with his or her single floral tribute.

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY

BY CHARLES T. LUPTON

1909. "The Eastern Part of the Bull Mountain Coal Field, Montana." *Bull. 431-B*. pp. 163–89, Pls. vi–vii.

1910. (With R. W. Stone) "The Powder River Coal Field, Wyoming, Adjacent to the Burlington Railroad." *Bull. 381-B*, pp. 115–36, Pl. viii.

1910. "The Deep Creek District of the Vernal Coal Field, Unita County, Utah." *Bull. 471-I*, pp. 579–94, Pl. lx.

1910. "The Blacktail (Tabby) Mountain Coal Feld, Wasatch County, Utah." *Bull. 471-I*, pp. 595–628, Pls. lxi-lxii.

1911. "Gypsum Along the West Flank of the San Rafael Swell, Utah." *Bull. 530-N*, pp. 221–31, Pl. v.

1912. "Oil and Gas Near Green River, Grand County, Utah." *Bull. 541-D*, pp. 115–33, Pl. vi.

1913. "Oil and Gas in the Western Part of the Olympic Peninsula, Washington." *Bull. 581-B*, pp. 23–81, Pl. ii.

1915. "The Orofino Coal Feld, Clearwater, Lewis, and Idaho Counties, Idaho," *Bull. 621-I*, pp. 99–108.

1915. "Oil and Gas Near Basin, Big Horn County, Wyoming." *Bull. 621-L*, pp. 157–90, Pls. xvii–xviii.

1916. "Geology and Coal Resources of Castle Valley in Carbon, Emery, and Sevier Counties, Utah." *Bull. 628*, 88 pp., 12 pls.

1917. (With D. D. Condit) "Gypsum in the Southern Part of the Bighorn Mountains, Wyoming." *Bull. 640-H*, pp. 139–57, Pls. iii–v.

1917. (With L. H. Woolsey and R. W. Richards) "The Bull Mountain Coal Field, Musselshell and Yellowstone Counties, Montana." *Bull. 647*. 218 pp., 36 pls.

1917. (With D. F. Hewett) "Anticlines in the Southern Part of the Big Horn Basin, Wyoming." (A Preliminary Report on the Occurrence of Oil.) *Bull. 656*, 192 pp., 32 pls.

ASSOCIATION PUBLICATIONS BY CHARLES T. LUPTON

1921. (With Wallace Lee) "Geology of the Cat Creek Oil Field, Fergus and Garfield Counties, Montana," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 5, No. 2 (March–April, pp. 252–75.

1922. (With Wallace Lee and Lisle Reed Van Burgh) "Oil Possibilities of Western Kansas," *ibid.*, Vol. 6, No. 2 (March–April), pp. 69–90.

1923. "Results and Prospects of Deeper Drilling in the Rocky Mountain Fields," *ibid.*, Vol. 7, No. 4 (July–August), pp. 400–10.

C. J. HARES

DENVER, COLORADO
February, 1936

BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 20, NO. 4 (APRIL, 1936), PP. 516-520

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

EDWARD A. KOESTER has resigned his position in the geological department of the Darby Petroleum Corporation at Wichita, Kansas, to accept a position in the exploration department of W. C. McBride, Incorporated, at McPherson, Kansas.

KENNETH B. NOWELS, geologist with the Forest Development Company, who recently moved to San Angelo, Texas, from Bradford, Pennsylvania, is now in the company's office at Abilene.

At the regular monthly meeting of the San Antonio Geological Society, February 17, a paper entitled "Plymouth and Taft Fields of San Patricio County, Texas," was presented by M. J. COLLINS and LEAVITT CORNING, JR., of the Plymouth Oil Company. The following new officers were elected for the year: president, ADOLPH DOVRE; vice-president, WILLIAM G. KANE; secretary-treasurer, HARRY H. NOWLAN; and member of the executive committee, W. K. ESGEN.

H. B. THOMSON has resigned his position as division production engineer with The Pure Oil Company, Saginaw, Michigan, and has taken a position as industrial heating engineer with Baker-Perkins Company, Saginaw.

The North Texas Geological Society held a dinner and meeting February 28 at the Wichita Club, Wichita Falls, Texas. ROBERT ROTH, Humble Oil and Refining Company, presented a paper, "Notes on the Base of the Custer."

F. S. WILLIAMS, geologist with W. C. McBride, Incorporated, has been transferred from the McPherson, Kansas, office to Tulsa, Oklahoma, where he will have charge of geological work in Kansas and Oklahoma.

NORMAN D. NEWELL, of the Kansas State Survey, recently spoke before the Kansas Geological Society, Wichita, on "Recent Investigations in Eastern Kansas."

CHARLES E. CLOWE, Ardmore, was elected president of the Southern Oklahoma Oil and Gas Association at their convention held in Ardmore recently.

HUGH L. BURCHFIEL, formerly at Tampa, Florida, may now be addressed in care of The California Company, Tower Petroleum Building, Dallas, Texas.

A. VAN WEELDEN, who spent several months in North and Central American oil fields, has returned to his home in The Hague, Holland. His address is De Bataafsche Petroleum Maatschappij, Carel Van Bylandtlaan 30.

C. WIEDENMAYER, geologist with the Standard Oil Company, has been transferred from Maracaibo to Caripito, Venezuela.

At a meeting of the Tulsa Geological Society, February 17, J. A. MCCUTCHIN, Shell Petroleum Corporation, Pampa, Texas, presented a paper entitled,

"Relation of Earth Temperature to Geological Structure." On March 2, C. W TOMLINSON, Ardmore, Oklahoma, presented two subjects, "Structural History of the Criner Hills" and "Opposed Thrusts or Scissor Faults in Southern Oklahoma."

DON G. BENSON, formerly with Deep Rock Oil Company, Ada, Oklahoma, has taken a position as geologist and scout with Sinclair Prairie Oil and Gas Company, and is located at Amarillo, Texas.

GEORGE M. BEVIER, geologist of Houston, Texas, has conveyed $10,000 to the University of Pittsburgh, Pennsylvania, the income to be used for the School of Mines, of which he is a graduate. Bevier served as assistant State geologist of Pennsylvania from 1913 to 1915.

CECIL VERNON HAGEN, formerly of San Antonio, Texas, recently accepted a position with the Superior Oil Company of California, and is located at Houston.

H. A. STEWART, formerly in charge of the geological and land departments of the Rocky Mountain division of The Texas Company, Denver, Colorado, has been advanced to division manager in charge and will assume active management of the Rocky Mountain activities of the producing department of the company.

SYLVAIN J. PIRSON, formerly with Seismograph Service Corporation, Tulsa, Oklahoma, is now with the Gulf Research and Development Corporation, Pittsburgh, Pennsylvania.

The following papers have recently been presented before the Rocky Mountain Association of Petroleum Geologists, Denver: February 17, "The Lance Creek Oil Field, Wyoming," by A. E. BRAINERD and C. S. LAVINGTON; March 2, "The Origin of the Helium in Helium Rich Natural Gases," by H. W. C. PROMMEL.

N. C. DAVIES has resigned his position with the Cities Service Companies and is now with the Empire Gas and Fuel Company, Wellsville, New York.

The Institution of Petroleum Technologists (London) announces the following. A meeting of members of the Institution in the United States will be held in Tulsa on May 15, 1936, the day before the opening of the 9th International Petroleum Exposition, May 16–23. A dinner will be held at the Hotel Mayo on the evening of May 15. Addresses will be given by GUSTAV EGLOFF of Chicago, and ROBERT E. WILSON of New York. It is hoped that WALLACE E. PRATT will also be able to address the meeting.

JOHN M. LOVEJOY is the new president of the American Institute of Mining and Metallurgical Engineers succeeding H. A. BUEHLER.

ROBERT D. LONGYEAR has an article, "Core Drills in Ancient Egypt," in *Mining and Metallurgy* for March, 1936.

W. H. BUCHER, professor of historical geology at the University of Cincinnati, lectured at Northwestern University, Evanston, Illinois, on the following dates: March 16, "Epeirogenic Deformation and Problems of the Continental Shelves"; March 17, "Orogenic Deformation and the Question of

Horizontal Movements," and "Measuring the Fourth Dimension"; March 18, "Rocky Mountain Type of Structure and the Question of Vertical Movements"; March 19, "Cryptovolcanic Structures and the Problem of the Heart Mountain Thrust." W. E. POWERS, professor at Northwestern, lectured at Cincinnati on physiographic problems, especially of glacial deposits and of southern Rocky Mountains.

The organization committee of the 17th session of the International Geological Congress, at Moscow, U.S.S.R., August, 1937, has issued a report by V. BILIKIN, "Methods of Estimating Underground Oil Reserves" (24 pages, in English), as a guide for others who may submit reports of reserves in their country, district, or field. The report is in the Association library, Tulsa, Oklahoma, and may be borrowed by members. Discussions and manuscripts for the Congress should be sent to the Organization Committee, I. M. GOUBKIN, chairman, Moscow, 10, U.S.S.R., Sretenka, 8.

STEPHEN REID CAPPS, geologist of the Alaskan Branch of the United States Geological Survey, delivered the U. S. Grant memorial lectures before the department of geology and geography at Northwestern University, Evanston, Illinois, February 25, 26, and 27, 1936. The subjects were "The Exploration and Development of Alaska," "The Geologic Provinces of Alaska," "The Geology of Kodiak and Adjacent Islands," and "Glaciation in Alaska."

VICTOR OPPENHEIM, engineer and geologist with the Department of Mines of Brazil, has returned to Rio de Janeiro after spending five months in exploration in the upper Amazon Valley in the border region between Brazil and Peru.

MARK C. MALAMPHY, of the Geological and Mineralogical Institute of Brazil, reports the organization of a new mining society at Rio de Janeiro, known as the Instituto Brasileiro de Mineração e Metallurgica, with more than 100 charter members. The I.B.M.M. will publish an illustrated technical bi-monthly review in Portuguese with comprehensive abstracts in English. Members of the A.A.P.G., who might visit Rio de Janeiro, are cordially invited to attend meetings. Further information will be given by MARK C. MALAMPHY, Prudente de Moraes 451, Rio de Janeiro, Brasil, S. A.

The Republic of Turkey, realizing the importance of mineral investigation in a scientific manner, has formed an Institute to investigate and explore for deposits of (1) petroleum, (2) metallic minerals, (3) coals, lignites, bituminous shales, and also to develop the chemical industries. DJEVAD EYOUB is in charge of the explorations for petroleum.

M. A. HARRELL, recently with the United States Geological Survey, may be addressed at Box 3092, Houston, Texas, in care of the Stanolind Oil and Gas Company.

N. H. DARTON, on February 1, 1936, celebrated the 50th anniversary of his entry into Government service. Most of this period has been spent with the United States Geological Survey.

The fourth annual Mineral Industries Conference of Illinois, in which the state's mineral and engineering organizations will participate, will be held at Urbana, Illinois, April 24 and 25, according to an announcement made by

M. M. LEIGHTON, chief of the Illinois State Geological Survey. The conference will be sponsored by the Geological Survey Division of the State Department of Registration and Education, the Engineering Experiment Station of the University of Illinois, and the Illinois Mineral Industries Committee.

MELVIN J. COLLINS, district geologist of the Plymouth Oil Company, died at San Antonio, Texas, March 22, from a sudden heart attack.

JACK HARVEY BROWN has joined the geological department of the Shell Petroleum Corporation at Tulsa.

P. E. FITZGERALD, geologist with Dowell, Incorporated, made the Pacific Coast Club, Long Beach, California, his headquarters last February.

JOHN S. REDFIELD, of the Stanolind Oil and Gas Company, has been appointed editor of the Tulsa Geological Society in place of T. C. HIESTAND, who has moved to Bartlesville, Oklahoma.

NOEL H. STEARN, chief geologist for W. C. McBride, Inc., St. Louis, Missouri, has an article, "The Cinnabar Deposits in Southwestern Arkansas," in *Economic Geology* for January-February, 1936.

The following are officers of the Society of Economic Geologists for 1936: president, D. F. HEWETT; secretary, D. H. MCLAUGHLIN; president-elect, RENO H. SALES; vice-president, JOHN W. FINCH; treasurer, W. B. HEROY; vice-president elect, ADOLPH KNOPF.

FREDERICK G. CLAPP, consulting geologist, 50 Church Street, New York, has an article, "The Past Year in Foreign Developments," in the *Oil Weekly* of January 27, 1936.

OTTO STUTZER, of the Saxony Mining School, Freiberg, Saxony, Germany, and past-president of the Society of Economic Geologists, has been in the United States for several months.

The second World Petroleum Congress will be held in Paris, June, 1937, according to Circular No. 1 (January, 1936) of the organization committee of the French Association of Petroleum Technologists. This is also the occasion of the International Exposition. The general procedure of the first Congress, held in London, will be followed. Papers and discussions will be grouped in 5 sections: (1) geology and production, (2) physical chemistry and refining, (3) material and construction, (4) technique of utilization of liquid fuels, and (5) economy and statistics. The price of registration as a member of the Congress is 50 francs; persons accompanying members may register for 25 francs. The official language is to be French, but correspondence and conferences may be carried on in English. Registration should be sent by April 1, 1937, and manuscripts should be submitted before February 1, 1937, to Secrétariat Géneral du Congrès, 85, Boulevard Montparnasse, Paris VI°. Copies of *Circulaire No. 1* (in French) giving more details, are available at A.A.P.G. headquarters, Box 1852, Tulsa, Oklahoma.

NORMAN HARDY, who for the past four years has been doing geological work for the Standard Oil Company of California in Netherlands, East Indies, was married on December 7, 1935, to Miss Laura Shaver, who until her mar-

riage was connected with the Barnsdall Oil Company in Los Angeles. Hardy has recently been transferred to the office of the Nederlandsche Pacific Petroleum Maatschappij, at The Hague.

The Richmond Petroleum Company, Standard Oil Company of California subsidiary, has recently discovered a new oil field in the Tehuantepec district of Mexico, on the Acalspa structure. The first well was a gasser but the second well obtained oil and is now flowing at the rate of about 1,300 barrels per day.

HERMAN DAVIES has been made manager of the northern division (Rocky Mountains) of The California Company.

The ninth International Petroleum Congress and Exposition is to be held at Tulsa, Oklahoma, from Saturday, May 16, through Saturday, May 23, 1936. Friday, May 22, has been designated Geologists and Oil Scouts Day.

ROBERT M. WHITESIDE has resigned from the geological department of the Shell Petroleum Corporation to engage in consulting work. After a trip of a few weeks on vacation and business in Texas, he will return to 15 West Tenth Street, Tulsa.

ADOLPH DOVRE has resigned his position as district geologist for the Tide Water Oil Company, which he has held for the past 7 years, and will engage in independent geological work. His office is 710 Milam Building, San Antonio, Texas.

The geological road map of the Pan-American Highway from Laredo to Mexico City, as used on the San Antonio Geological Society field trip to the midyear meeting of the Association in Mexico City, may be purchased from the San Antonio Society, 525 Milam Building, San Antonio, Texas, or from Association headquarters, Box 1852, Tulsa, Oklahoma. The large map, 51×14 inches, hand colored on paper, with a printed pamphlet giving the road mileage, is priced at $3.00. A smaller map, about 34×11 inches, also hand colored, and with the printed road log, is priced at $2.00.

CHARLES A. MILMER, JR., has been appointed secretary-treasurer of the Ardmore Geological Society to fill the vacancy created by the resignation of R. B. ANDERSON, who has moved to West Virginia.

W. O. THOMPSON spoke on "Original Structures in Various Kinds of Sandstones" before the Rocky Mountain Association of Petroleum Geologists, at Denver, Colorado, April 6, 1936.

At the recent annual meeting of the Association of American State Geologists in Washington, D. C., the officers elected were: GEORGE C. BRANNER, State geologist of Arkansas, president; ARTHUR BEVAN, State geologist of Virginia, secretary; and RAYMOND C. MOORE, State geologist of Kansas, third member of executive committee.

GEORGE H. FANCHER, professor of petroleum engineering, University of Texas, gave a talk on "Physical Properties of Reservoir Strata" at the weekly luncheon of the Houston Geological Society, Thursday, March 12, 1936.

The Appalachian Geological Society has recently published a *Symposium on Devonian Shales*, Vol. I, which is composed of nine papers and maps dealing with origin, accumulation, areal extent, development, and estimate of reserves in eastern Kentucky and western West Virginia. This symposium can be secured from the secretary-treasurer of the Society, R. C. LAFFERTY, Box 1240, Charleston, West Virginia. Price to members of the A.A.P.G., $2.00; non-members, $2.50.

PROFESSIONAL DIRECTORY

Space for Professional Cards Is Reserved for Members of the Association. For Rates Apply to A.A.P.G. Headquarters, Box 1852, Tulsa, Oklahoma

CALIFORNIA

WILLARD J. CLASSEN
Consulting Geologist
Petroleum Engineer
1093 Mills Building
SAN FRANCISCO, CALIFORNIA

RICHARD R. CRANDALL
Consulting Geologist
415 Haas Building
LOS ANGELES, CALIFORNIA

J. E. EATON
Consulting Geologist
2062 N. Sycamore Avenue
LOS ANGELES, CALIFORNIA

PAUL P. GOUDKOFF
Geologist
Geologic Correlation by Foraminifera and Mineral Grains
799 Subway Terminal Building
LOS ANGELES, CALIFORNIA

C. R. McCOLLOM
Consulting Geologist
Richfield Building
LOS ANGELES, CALIFORNIA

WALTER STALDER
Petroleum Geologist
925 Crocker Building
SAN FRANCISCO, CALIFORNIA

IRVINE E. STEWART
Consulting Geologist
548 Subway Terminal Building
LOS ANGELES, CALIFORNIA

COLORADO

HEILAND RESEARCH CORPORATION
Registered Geophysical Engineers
— Instruments —
— Surveys — Interpretations —
C. A. HEILAND, *President*
CLUB BLDG., *Denver, Colo.*

JOHN H. WILSON
Geologist and Geophysicist
Colorado Geophysical Corporation
610 Midland Savings Building, DENVER, COLORADO

CZECHOSLOVAKIA

DR. HANS HLAUSCHEK
Consulting Geologist
Prague XVI, nabr. legií 10
CZECHOSLOVAKIA

KANSAS

L. C. MORGAN
Petroleum Engineer and Geologist
Specializing in Acid-Treating Problems
358 North Dellrose
WICHITA, KANSAS

LOUISIANA

J. Y. SNYDER
1211 City Bank Building
SHREVEPORT, LOUISIANA
No Commercial Work Undertaken

WILLIAM M. BARRET, INC.
Consulting Geophysicists
Specializing in Magnetic Surveys
Giddens-Lane Building SHREVEPORT, LA.

NEW MEXICO

RONALD K. DEFORD
Geologist
ROSWELL, NEW MEXICO
MIDLAND, TEXAS

NEW YORK

BROKAW, DIXON & McKEE
Geologists *Engineers*
OIL—NATURAL GAS
Examinations, Reports, Appraisals
Estimates of Reserves
120 Broadway, New York
Gulf Building, Houston

E. DEGOLYER
Geologist
Room 1710, Esperson Building, Houston, Texas
Room 2715, 120 Broadway, New York, N.Y.

FREDERICK G. CLAPP
Consulting Geologist
50 Church Street
NEW YORK

A. H. GARNER
Geologist *Engineer*
PETROLEUM
NATURAL GAS
120 Broadway New York, N.Y.

OHIO

JOHN L. RICH
Geologist
Specializing in extension of "shoestring" pools
University of Cincinnati
Cincinnati, Ohio

PENNSYLVANIA

HUNTLEY & HUNTLEY
Petroleum Geologists and Engineers
L. G. HUNTLEY
J. R. WYLIE, JR.
Grant Building, Pittsburgh, Pa.

OKLAHOMA

ELFRED BECK
Geologist
614 National Bank of Tulsa Building
TULSA OKLAHOMA

GINTER CHEMICAL LABORATORY
Analytical Work on Oil, Gas, Water and Cores
R. L. GINTER, *Owner*
118 West Cameron
Tulsa

R. W. Laughlin L. D. Simmons
WELL ELEVATIONS
Oklahoma, Kansas, Texas, and New Mexico
LAUGHLIN-SIMMONS & CO.
605 Oklahoma Gas Building
TULSA OKLAHOMA

GEO. C. MATSON
Geologist
Philcade Building TULSA, OKLA.

G. H. WESTBY
Geologist and Geophysicist
Seismograph Service Corporation
Kennedy Building Tulsa, Oklahoma

TEXAS

DONALD C. BARTON
Geologist and Geophysicist
Humble Oil and Refining Company
HOUSTON TEXAS

D'ARCY M. CASHIN
Geologist *Engineer*
Specialist, Gulf Coast Salt Domes
Examinations, Reports, Appraisals
Estimates of Reserves
705 Nat'l Standard Bldg.
HOUSTON, TEXAS

DAVID DONOGHUE
Consulting Geologist
Appraisals - Evidence - Statistics
Fort Worth National Bank Building FORT WORTH, TEXAS

ALEXANDER DEUSSEN
Consulting Geologist
Specialist, Gulf Coast Salt Domes
1606 Shell Building
HOUSTON, TEXAS

J. S. HUDNALL G. W. PIRTLE
HUDNALL & PIRTLE
Petroleum Geologists
Appraisals Reports
Peoples Nat'l Bank Bldg. TYLER, TEXAS

F. B. Porter, *President* R. H. Fash, *Vice-President*
THE FORT WORTH LABORATORIES
Analyses of Brines, Gas, Minerals, Oil. Interpretation of Water Analyses. Field Gas Testing.
828½ Monroe Street FORT WORTH, TEXAS
Long Distance 138

TEXAS

JOHN S. IVY
United Gas System
921 Rusk Building, HOUSTON, TEXAS

W. P. JENNY
Geologist and Geophysicist
Gravimetric Seismic
Magnetic Electric
Surveys and Interpretations
2102 Bissonett HOUSTON, TEXAS

PHILLIP MAVERICK
Petroleum Geologist
Western Reserve Life Building
SAN ANGELO TEXAS

DABNEY E. PETTY
Geologist
P. O. Drawer 1477 SAN ANTONIO, TEXAS

E. E. Rosaire F. M. Kannenstine
ROSAIRE & KANNENSTINE
Consulting Geophysicists
Specializing in
Seismograph Explorations
Esperson Building HOUSTON, TEXAS

A. T. SCHWENNESEN
Geologist
1517 Shell Building
HOUSTON TEXAS

OLAF F. SUNDT
Geologist and Geophysicist
Specializing in Gravity Work
Sterling Building Phone Preston 8582
Box 962 Houston, Texas

W. G. Saville J. P. Schumacher A. C. Pagan
TORSION BALANCE
EXPLORATION CO.
Torsion Balance Surveys
1028-30 Post Dispatch Bldg. Phone: Preston 7315
HOUSTON, TEXAS Cable: Torbalex

HAROLD VANCE
Petroleum Engineer
Petroleum Engineering Department
A. & M. College of Texas
COLLEGE STATION, TEXAS

WYOMING

E. W. KRAMPERT
Consulting Geologist
P.O. Box 1106
CASPER, WYOMING

GEOLOGICAL AND GEOPHYSICAL

COLORADO

ROCKY MOUNTAIN ASSOCIATION OF PETROLEUM GEOLOGISTS

DENVER, COLORADO

President - - - - - - - - Ross L. Heaton
2374 Elm Street
Vice-President - - - - - W. C. Toepelman
University of Colorado, Boulder
Vice-President - - - - - - H. W. Oborne
Box 37, Colorado Springs
Secretary-Treasurer - - - J. Harlan Johnson
Box 336, Colorado School of Mines, Golden, Colo.

Luncheon meetings, first and third Mondays of each month, 6:15 P.M., Auditorium Hotel.

LOUISIANA

THE SHREVEPORT GEOLOGICAL SOCIETY

SHREVEPORT, LOUISIANA

President - - - - - - - - Paul E. Nash
Magnolia Petroleum Company
Vice-President - - - - - B. W. Blanpied
Gulf Refining Company
Secretary-Treasurer - - - Shapleigh G. Gray
The Texas Company

Meets the first Friday of every month, Civil Courts Room, Caddo Parish Court House. Luncheon every Monday noon, Caddo Hotel.

KANSAS

KANSAS GEOLOGICAL SOCIETY

WICHITA, KANSAS

President - - - - - - - R. H. Whortan
705 Fourth National Bank Building
Vice-President - - - - - Charles W. Roop
I.T.I.O. Co., 605 Union National Bank Building
Secretary-Treasurer - - - - B. S. Ridgeway
Empire Oil and Refining Co., 409 Kaufman Bldg.

Regular Meetings: 7:30 P.M., Allis Hotel, first Tuesday of each month. Visitors cordially welcomed.

The Society sponsors the Kansas Well Log Bureau which is located at 412 Union National Bank Building.

THE SOCIETY OF PETROLEUM GEOPHYSICISTS

President - - - - - - - - L. W. Blau
Humble Oil and Refining Company
Houston, Texas
Vice-President - - - - - Gerald W. Westby
Seismograph Service Corporation
Tulsa, Oklahoma
Editor - - - - - - F. M. Kannenstine
Rosaire and Kannenstine
2011 Esperson Building
Houston, Texas
Secretary-Treasurer - - - John H. Wilson
Colorado Geophysical Corporation
610 Midland Savings Building
Denver, Colorado

OKLAHOMA

OKLAHOMA CITY GEOLOGICAL SOCIETY

OKLAHOMA CITY, OKLAHOMA

President - - - - - - - R. W. Laughlin
First National Building
Vice-President - - - - Leland W. Jones
Marathon Oil Company
Secretary-Treasurer - - - - Henry Schweer
2810 First National Building

Meetings: Second Monday, each month, 8:00 P.M., Commerce Exchange Building. Luncheons: Every Monday, 12:15 P.M., Commerce Exchange Building.

SHAWNEE GEOLOGICAL SOCIETY

SHAWNEE, OKLAHOMA

President - - - - - - - W. D. Henderson
Stanolind Oil and Gas Company
Vice-President - - - - - - W. H. Wynn
Sinclair-Prairie Oil and Gas Company
Secretary-Treasurer - - - H. W. O'Keeffe
Phillips Petroleum Company

Meets the fourth Monday of each month at 7:00 P.M., at the Aldridge Hotel. Visiting geologists welcome.

THE STRATIGRAPHIC SOCIETY OF TULSA

TULSA, OKLAHOMA

President - - - - - - Glenn S. Dillé
1632 South Cheyenne Avenue
Vice-President - - - - - - Joseph L. Borden
The Pure Oil Company
Secretary-Treasurer .....R. E. Minnes
The Tide Water Oil Company

Meetings: Second and fourth Wednesdays, each month, from October to May, inclusive, at 8:00 P.M., third floor, Tulsa Building.

TULSA GEOLOGICAL SOCIETY

TULSA, OKLAHOMA

President - - - - - - - R. B. Rutledge
Skelly Oil Company
1st Vice-President - - - - G. S. Lambert
Shell Petroleum Corporation
2nd Vice-President - - Lucian H. Walker
614 Atlas Life Building
Secretary-Treasurer - - - Larry D. Simmons
Oklahoma Natural Gas Building
Editor - - - - - - - - John S. Redfield
Stanolind Oil and Gas Company

Meetings: First and third Mondays, each month, from October to May, inclusive, at 8:00 P.M., fourth floor, Tulsa Building. Luncheons: Every Thursday, fourth floor, Tulsa Building.

SOCIETIES

For Space Apply to A.A.P.G. Headquarters
Box 1852, Tulsa, Oklahoma

TEXAS

DALLAS PETROLEUM GEOLOGISTS

DALLAS, TEXAS

President - - - - - - - - H. J. Hawley
The California Company

Vice-President - - - - - Charles B. Carpenter
U. S. Bureau of Mines

Secretary-Treasurer - - - - - - R. A. Stehr
Texas Seaboard Oil Company

Meetings will be announced.

FORT WORTH GEOLOGICAL SOCIETY

FORT WORTH, TEXAS

President - - - - - - Norman L. Thomas
The Pure Oil Company

Vice-President - - - - - - J. F. Hosterman
Amerada Petroleum Corporation

Secretary-Treasurer - - - - - Paul C. Dean
1818 W. T. Waggoner Building

Meetings: Luncheon at noon, Worth Hotel, every Monday. Special meetings called by executive committee. Visiting geologists are welcome to all meetings.

HOUSTON GEOLOGICAL SOCIETY

HOUSTON, TEXAS

President - - - - - - Merle C. Israelsky
United Gas Company

Vice-President - - - - - Phil F. Martyn
Houston Oil Company of Texas

Secretary-Treasurer - - - - - O. L. Brace
813 Second National Bank Building

Regular meetings, every Thursday at noon (12:15) at the Houston Club. Frequent special meetings called by the executive committee. For any particulars pertaining to meetings call the secretary.

NORTH TEXAS GEOLOGICAL SOCIETY

WICHITA FALLS, TEXAS

President - - - - - - - - - Tom L. Coleman
United States Geological Survey

Vice-President - - - - - - - - - Robert Roth
Humble Oil and Refining Company

Secretary-Treasurer - - - - - S. G. Waggoner
2013 Brown Street

Meetings: Second Friday, each month, at 6:30 P.M.
Luncheons: Fourth Friday, each month, at 12:15 P.M.
Place: Hamilton Building

EAST TEXAS GEOLOGICAL SOCIETY

TYLER, TEXAS

President .....H. J. McLellan
Humble Oil and Refining Company

Vice-President .....J. W. Kisling, Jr.
Amerada Petroleum Corporation

Secretary-Treasurer .....George W. Pirtle
Hudnall and Pirtle, Consulting Geologists

Meetings: Monthly and by call.

•Luncheons: Every Friday, Cameron's Cafeteria.

WEST TEXAS GEOLOGICAL SOCIETY

SAN ANGELO AND MIDLAND, TEXAS

President - - - - - - - E. Russell Lloyd
Box 1106, Midland

Vice-President - - - - - - - P. D. Moore
Consulting Geologist, San Angelo

Secretary-Treasurer - - - - - M. B. Arick
Humble Oil and Refining Company, Midland

Meetings will be announced

WEST VIRGINIA

THE APPALACHIAN GEOLOGICAL SOCIETY

CHARLESTON, WEST VIRGINIA

President - - - - - - J. E. Billingsley
Commonwealth Gas Corporation
401 Union Building

Vice-President - - - - - Charles E. Krebs
Consulting Geologist and Engineer

Secretary-Treasurer - - - Robert C. Lafferty
Columbian Carbon Company, Box 1240

Meetings: Second Monday, each month, at 6:30 P.M., Ruffner Hotel.

WELL LOGS

Refer your Well Log Problems to Specialists

Write for samples

THE MID-WEST PRINTING CO., BOX 766, TULSA, OKLAHOMA

GEOLOGY OF SALT DOME OIL FIELDS

Cloth-bound copies of this symposium, published by the Association in 1926, will be purchased, subject to examination, at $15.00 per copy.

The American Association of Petroleum Geologists, Box 1852, Tulsa, Oklahoma

REVUE DE GÉOLOGIE
et des Sciences connexes

RASSEGNA DI GEOLOGIA
e delle Scienze affini

REVIEW OF GEOLOGY
and Connected Sciences

RUNDSCHAU FÜR GEOLOGIE
und verwandte Wissenschaften

Abstract journal published monthly with the coöperation of the FONDATION UNIVERSITAIRE DE BELGIQUE and under the auspices of the SOCIÉTÉ GÉOLOGIQUE DE BELGIQUE with the collaboration of several scientific institutions, geological surveys, and correspondents in all countries of the world.

GENERAL OFFICE, *Revue de Géologie*, Institut de Géologie, Université de Liége, Belgium.

TREASURER, *Revue de Géologie*, 35, Rue des Armuriers, Liége, Belgium.

Subscription, Vol. XVI (1936), 35 belgas *Sample Copy Sent on Request*

The Annotated

Bibliography of Economic Geology
Vol. VII, No. 1

Is Now Ready

Orders are now being taken for the entire volume at $5.00 or for individual numbers at $3.00 each. Volumes I, II, III, IV. V, and VI can still be obtained at $5.00 each.

The number of entries in Vol. I is 1,756. Vol. II contains 2,480, Vol. III, 2,260, Vol. IV, 2,224, Vol. V, 2,225, and Vol. VI, 2,085.

Of these, 3,385 refer to *petroleum, gas*, etc., and *geophysics*. They cover the world.

If you wish future numbers sent you promptly, kindly give us a *continuing* order.

Economic Geology Publishing Co.
Urbana, Illinois, U. S. A.

THE JOURNAL OF GEOLOGY

a semi-quarterly

Edited by

ROLLIN T. CHAMBERLIN

Since 1893 a constant record of the advance of geological science. Articles deal with problems of systematic, theoretical, and fundamental geology. Each article is replete with diagrams, figures, and other illustrations necessary to a full scientific understanding.

$6.00 a year
$1.00 a single copy

Canadian postage, 25 cents
Foreign postage, 65 cents

THE UNIVERSITY OF CHICAGO PRESS

TULSA, The World's Oil Capital

Where one can find a greater concentration of major oil company headquarters than in any other city in America. And the Petroleum Geologist knows that this means executive offices and operating headquarters—the source of geological assignments.

- **TULSA is National Headquarters for the leading associations of the oil industry, including the A.A.P.G., and is ideally situated as a convention city for these great oil organizations. Residents of Tulsa come in personal contact with leaders of all branches of the industry many times a year.**
- **TULSA is the home of the great International Petroleum Exposition, which will be held on May 16-23, 1936, and which attracts many thousands of oil men, and is the world's greatest annual concentration of leaders in the industry.**
- **The Technical Department of the Tulsa Public library is the world's most comprehensive petroleum library. For many years this department has purchased every new book on petroleum and gas, has complete files of 64 technical journals and of the publications of the U.S.G.S., the U. S. Bureau of Mines, and all state geological reports.**
- **TULSA is a metropolitan city, with superior public schools, fine churches, 2,500 acres of parks and playgrounds, varied sports and amusements, and, all in all, is an ideal city in which to live and earn a livelihood.**

For further particulars write

THE TULSA CHAMBER of COMMERCE

Another A.A.P.G. Book of Oil-Field Structure

Geology of Natural Gas

A symposium of The American Association of Petroleum Geologists
Edited by HENRY A. LEY

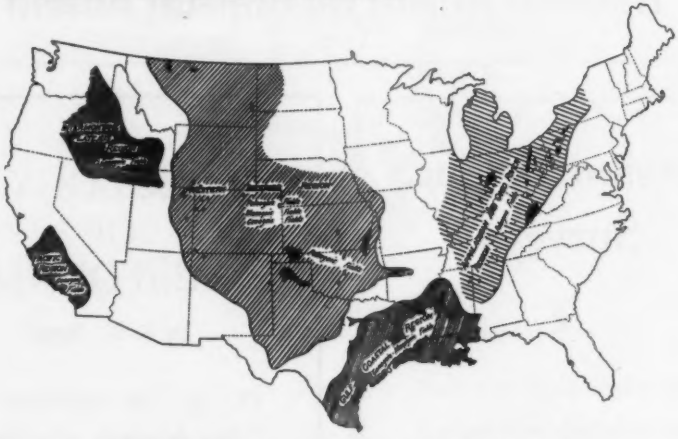
Here for the first time has been assembled a comprehensive geologic treatise of the occurrence of natural gas on the North American Continent.

- **1227 pages, including a carefully prepared index of 77 pages**
- **250 excellent illustrations, including Maps, Sections, Charts, Tables, Photographs**
- **Bound in Blue Cloth. 6 x 9 x 2 inches**

Articles on Fields in

Alberta
Ontario
Quebec
California
Washington
Idaho
Oregon
Utah
Montana
Wyoming
Colorado
New Mexico
Texas
Kansas
Oklahoma
Arkansas
Louisiana
Michigan
Illinois
Indiana
Kentucky
Ohio
Tennessee
Mississippi
Alabama
New York
Pennsylvania
West Virginia
Mexico

Valuation
Reserves
Helium
Rare Gases
The Industry



Reduced illustration showing natural gas regions in United States

"There is scarcely any important fact relative to North American gas, be it stratigraphical, structural, or statistical, that cannot be readily obtained from the volume."—Romanes in *Jour. Inst. Petrol. Tech.* (London).

Price, postpaid, only $4.50 to paid-up members and associates, $6.00 to others

The American Association of Petroleum Geologists
Box 1852 Tulsa, Oklahoma

Verlag von Gebrüder Borntraeger in Berlin W 35 (Deutschland)

Die wichtigsten Lagerstätten der „Nicht-Erze" von Prof. **Dr. O. Stutzer**

Band I: **Erdöl.** Allgemeine Erdölgeologie und Überblick über die Geologie der Erdölfelder Europas von Prof. Dr. **O. Stutzer.** Mit 199 Textabbild. (XVI u. 628 S.) 1931 Gebunden *RM* 62.—*

Band II: **Kohle, allgemeine Kohlengeologie.** Mit 44 Tafeln und 177 Textabbildungen. Zweite, vollständig erweiterte und umgearbeitete Auflage (XVIII u. 510 S.) 1923 Gebunden *RM* 40.50*

Band IV: **Phosphat** von Prof. Dr. **O. Stutzer.—Nitrat** von Prof. Dr. **W. Wetzel.** Mit 101 Abbildungen. (XV und 390 S.) 1932 Gebunden *RM* 34.—*

Band V: **Schwefel und Graphit** von Prof. Dr. **O. Stutzer.—Jod und Bor** von Prof. Dr. **W. Wetzel.—Magnesit und Talk** von Prof. Dr. **A. Himmelbauer.** Mit 106 Abbildungen. (X u. 396 S.) 1933 Gebunden *RM* 32.—*

Band VI: **Die Lagerstätten der Edelsteine** und **Schmucksteine** von Prof. Dr. **O. Stutzer** und Dr. **W. Fr. Eppler.** Mit 154 Textabbildungen. (XVIII u. 567 S.) 1935 Gebunden *RM* 45.50*

* Die deutschen Preise ermäßigen sich für das Ausland mit Ausnahme der Schweiz um 25%

Eusführliche Prospekte über Einzelwerke kostenfrei

Torsion Balance Surveys

Nine years Texas and Gulf Coast experience with regional surveys on which to base our interpretations.

COASTAL OIL FINDING CO.
Esperson Bldg., Houston

GEOLOGY OF CALIFORNIA

By R. D. Reed

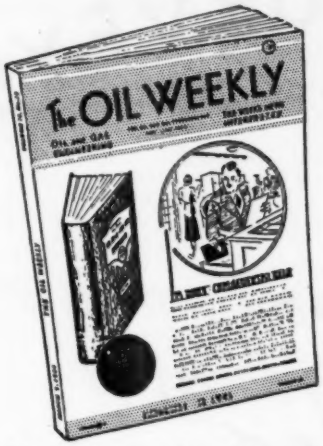
355 pp., 29 half-tones, 33 line drawings, 26 tables.
9 x 6 inches. Cloth
$5.00, postpaid

THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
Box 1852, Tulsa, Oklahoma

SEISMIC SURVEYS

INDEPENDENT EXPLORATION COMPANY

2011 ESPERSON BLDG.—HOUSTON, TEXAS



In Addition to publishing

246 Engineering and Technical Articles

in 1935, THE OIL WEEKLY carried weekly field reports on all important fields, oil-field maps showing geological data, an interpretation of the week's news, domestic and foreign developments of importance, editorials, markets, and statistics. Also a series on various district Crude Oil Reserves was introduced which is to be continued in future issues and eventually will cover every important area in the United States.

THE OIL WEEKLY is proud of its large circulation and growing popularity among petroleum geologists because it indicates that they are pleased with the up-to-date and accurate information as well as the technical articles covering geological work.

If you are not a subscriber, we invite you to use the coupon below. One year—52 issues—only $2.00.

Be sure to indicate your company and position—It will prevent delay in entering your subscription.

THE OIL WEEKLY,
Post Office Drawer 2811, Houston, Texas

Enter my subscription to THE OIL WEEKLY for which you will find enclosed check for $2.00 for one year.

Name .....

Street and No. .....

City and State .....

I am with the .....

and my position is: .....

FREE to PETROLEUM GEOLOGISTS

Be prepared for Spring field work by keeping an orderly, chronological record of all observations in running preliminary surveys or doing contour work. Mail the attached coupon today and let us send you, *free* of all cost or obligation, a copy of our Observation Record Book for noting and correcting all altimeter readings. No matter what equipment you use, mail the coupon for your copy of this handy book for your field kit. Sign and mail the coupon now, indicating whether or not you want new literature regarding the Paulin Surveying Aneroid.

The A-1 Paulin Altimeter with heavy leather carrying case. No field outfit is complete without at least one of these precision aneroids for quickly determining differences in elevation with accuracy.

Mail This Coupon for FREE Copy of the "Paulin Observation Record Book"

THE AMERICAN PAULIN SYSTEM
1847 SOUTH FLOWER STREET
LOS ANGELES, CALIF.

Place check mark in this square if you desire literature on the new Paulin Surveying Aneroid ☐

Please send me, without cost or obligation, a copy of your "Observation Record Book."

Name .....

Address ..... Post Office .....

Company .....

PROBLEMS OF PETROLEUM GEOLOGY

Sidney Powers Memorial Volume

A Sequel to *Structure of Typical American Oil Fields*

A compilation of 43 papers prepared for this volume by 47 authors; not previously published; in part read in preliminary form before annual meetings of The American Association of Petroleum Geologists

Edited by

W. E. WRATHER and F. H. LAHEE

Outline of Contents

Part I. History
Part II. Origin and Evolution of Petroleum. Group 1: Origin. Group 2: Carbon Ratios. Group 3: Variation in Physical Properties
Part III. Migration and Accumulation of Petroleum
Part IV. Relations of Petroleum Accumulation to Structure
Part V. Porosity, Permeability, Compaction
Part VI. Oil-Field Waters
Part VII. Subsurface Temperature Gradients

1,073 pp., 200 illus. Size, 6x9 inches. Cloth. Price, postpaid: to members and associates, $5.00; to non-members, $6.00. Usual discounts to agencies and educational institutions.

The American Association of Petroleum Geologists
Box 1852 ... Tulsa, Oklahoma

Have You Bought Your Copy?

STRUCTURE OF TYPICAL AMERICAN OIL FIELDS

VOLS. I-II

PRICE, $5.00 EACH, TO MEMBERS AND ASSOCIATES

This valuable collection of geological data is increasing the enviable scientific reputation of the Association. It is a distinctive publication. Only a few of these important papers are published in the Bulletin. Members and associates have the opportunity of securing one of these books at $5.00 per copy.

Volume I, 510 pp., 190 illus. Cloth. Price to non-members, postpaid, $7.00
Volume II, 780 pp., 235 illus. Cloth. Price to non-members, postpaid, $7.00

The American Association of Petroleum Geologists
BOX 1852, TULSA, OKLAHOMA, U. S. A.
London: Thomas Murby & Co., 1, Fleet Lane, E. C. 4

YEARS OF EXPERIENCE - -

Our Reflection Seismograph experience over the last five years, expressed in terms of single-crew operation, totals more than 500 months.

Constant research with resulting improvements in instruments and technique, and long and adequate training of personnel, enable us to offer a Service second to none.

Call or write us for further information.

Seismograph Service Corporation

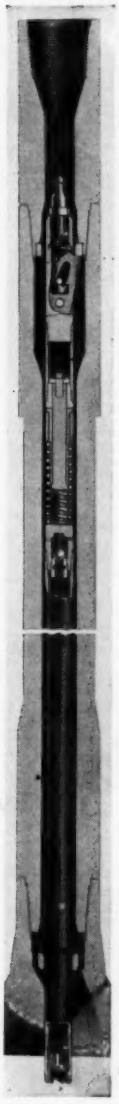
Kennedy Building, Telephones 2-8181 and LD 548.

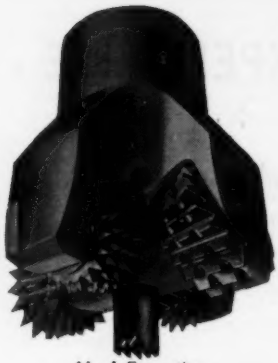
TULSA, U. S. A.

ENGINEERING LABORATORIES, Inc., Tulsa, Oklahoma

Engineering and Manufacturing Affiliate

WIRE LINE CORING IN ANY FORMATION WITH REED'S 'B-R' DRILLING BIT WITH WIRE LINE CORE BARREL





Hard Formation (Roller Type Cutter) Head

Soft Formation Head 2-3 or 4 Blade Interchangeable

Sample of cores taken on Sinclair-Prairie's Stockton No. 1 in Western Love County, Oklahoma

Any number of cores may be taken at any depth in any formation without removing the drill pipe

REED
ROLLER BIT COMPANY

HOUSTON, TEXAS
NEW YORK CITY
OKLAHOMA CITY, OKLA.
LOS ANGELES, CALIF.

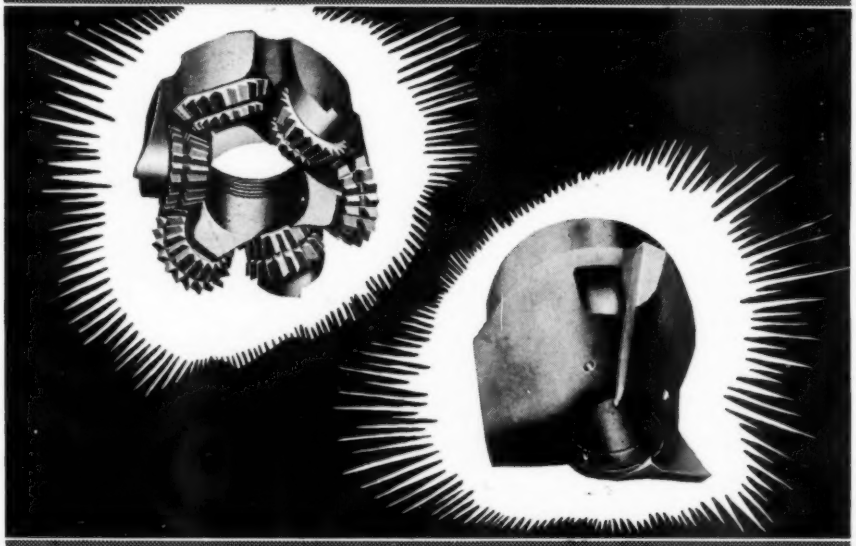
Reflection Seismic Surveys

Successfully Conducted in

MIDCONTINENT—Texas, Oklahoma, Kansas
GULF COAST—Texas, Louisiana, Alabama
PACIFIC COAST—California
ROCKY MOUNTAIN—Colorado, Wyoming, Montana
APPALACHIAN—Pennsylvania, New York
GREAT LAKES—Michigan
CANADA—Alberta, Saskatchewan, Quebec
MEXICO—Tampico Area, Isthmus of Tehuantepec
VENEZUELA

GEOPHYSICAL SERVICE
INCORPORATED
DALLAS, TEXAS

You "KNOW" The Formations



When You USE HUGHES CORE BITS

HUGHES TOOL COMPANY

SERVICE PLANTS
LOS ANGELES, CALIF.
OKLAHOMA CITY, OKLA.
MIDLAND, TEXAS

MAIN PLANT AND OFFICE:
HOUSTON,
TEXAS

EXPORT OFFICE:
30 ROCKEFELLER PLAZA
NEW YORK CITY